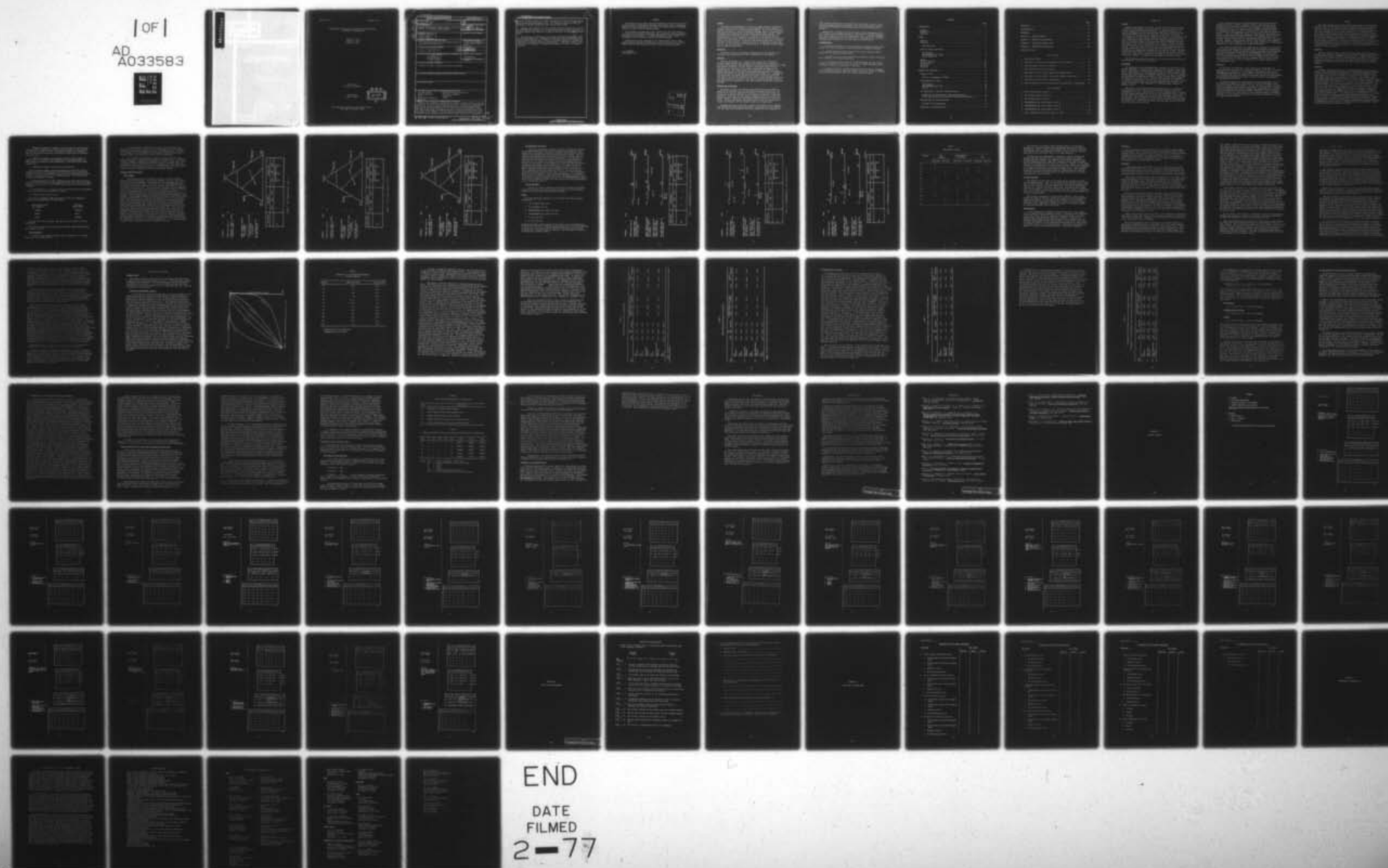
AD-A033 583 NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER SAN D--ETC F/G 15/7
SIGNIFICANCE OF RISK IN NAVY TACTICAL DECISION MAKING: AN EMPIR--ETC(U)
DEC 76 C F GETTYS, M C MOY, M W O'BAR

UNCLASSIFIED NPRDC-TR-77-8 NL

1 OF 1
AD
A033583



END
DATE
FILMED
2-77

NPRDC TR 77-8 December 1976

SIGNIFICANCE OF RISK IN NAVY TACTICAL DECISION MAKING: AN EMPIRICAL INVESTIGATION

Charles F. Gettys
Melvyn C. Moy
Michael W. O'Bar

Reviewed by
Richard C. Sorenson

Approved by
James J. Regan

Navy Personnel Research and Development Center
San Diego, California 92152

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (*When Data Entered*)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER 14 NPRDC-TR-77- 8	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER 9
4. TITLE (*and Subtitle*) 6 SIGNIFICANCE OF RISK IN NAVY TACTICAL DECISION MAKING: AN EMPIRICAL INVESTIGATION.		5. TYPE OF REPORT & PERIOD COVERED Final Rep[redacted]t. Feb [redacted] — Sep [redacted]76, 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) 10 Charles F. Gettys Melvyn C. Moy Michael W. O'Bar		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Navy Personnel Research and Development Center San Diego, California 92152		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 63720N; N000147IWRT0026; WR-60265
11. CONTROLLING OFFICE NAME AND ADDRESS Office of Naval Research Arlington, Virginia 22217		12. REPORT DATE 11 Dec[redacted]976 13. NUMBER OF PAGES 86
14. MONITORING AGENCY NAME & ADDRESS(*if different from Controlling Office*) 12 83p.		15. SECURITY CLASS. (*of this report*) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (*of this Report*)

Approved for public release; distribution unlimited

17. DISTRIBUTION STATEMENT (*of the abstract entered in Block 20, if different from Report*)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (*Continue on reverse side if necessary and identify by block number*)

Decision Aiding	Subjective Expected Utilities
Bayesian Revision	Task Force Commander
Risk	Likelihoods
Conditional Dependence	π-BRLT
Variance	

20. ABSTRACT (*Continue on reverse side if necessary and identify by block number*)

Research was conducted to determine the extent to which factors of risk are important in the use of operational decision aids. An empirical comparison was made between the performance of individuals using a decision aiding display developed by Decisions and Designs, Inc. (DDI), and the performance of these same individuals using a display developed by the Navy Personnel Research and Development Center (NPRDC). The DDI display was primarily designed to convey information about subjective expected utility (SEU) and does not explicitly

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED 390 772

SECURITY CLASSIFICATION OF THIS PAGE (*When Data Entered*)

LB

present information about the "risk" associated with each of the alternative acts the decision maker might select. The display contrived by NPRDC was designed to present information about risk as well as SEU.

Subjects who benefited from the aids were those who became more aversive to risk when the necessity of a correct decision was increased. However, no distinct benefit was found for the explicit inclusion of certain dimensions of risk.

The importance of providing for possible conditional dependencies among the data was emphasized. A suggestion is made for the restructuring of the basic decision task in order to avoid a deficiency inherent to the Bayesian algorithm for updating subjective probabilities. Attention is given to the reliability and validity of likelihood estimates to be used in a Bayesian revision.

FOREWORD

The purpose of this study, which was conducted in support of the Office of Naval Research's Operational Decision Aids Project, was to investigate empirically the significance of perceived risk considerations in designing displays for Navy tactical decision making.

The invaluable contributions of Ms. Cheron Vail, who participated in all phases of the software development, data collection, and data analysis, are gratefully acknowledged. Mr. Ramon Hershman also made valuable contributions to the project as software and systems analyst.

Appreciation is also expressed to the instructional staff at Fleet Combat Direction Systems Training Center, Pacific Tactical Action Officer School, who were participants during the study data gathering phase.

J. J. CLARKIN
Commanding Officer

SUMMARY

Problem

The Office of Naval Research, as part of a large project in Operational Decision Aiding, has contracted for the development of several decision analytic tools to aid in tactical decision making. Much of this development has occurred despite a lack of sufficient knowledge about the importance of perceived risk considerations in Navy operational decision making. "Risk" is defined as the relative certainty of the outcome associated with a selected action. If an individual is confident of the outcome that will result from a particular action on his part, the perceived risk of selecting that act is said to be low. Factors of risk have been observed to be very important in many decision situations and may be an important presence here as well. If so, risk may be too potent a factor to disregard in the development of these decision aids.

Objective

The present study is an empirical investigation of the importance of perceived risk considerations in Navy operational decision making.

Approach

Decision performance by 12 expert subjects using two versions of a decision aiding approach were compared. One version used a prototype decision aiding display that was developed by Decisions and Designs, Inc. (DDI). This display contained a minimal amount of information about the risk involved in the selection of the action alternatives available to the decision maker. The other version used a display which explicitly presented some aspects of risk and which included the same type of information that was present in the display by Decisions and Designs, Inc. Included in the display was information indicating the range of outcomes associated with each action and the probability that each of these outcomes would occur. The subjects used the displays to aid them in analyzing realistic tactical scenarios that were presented to them under supposed conditions of high and low risk.

Results and Conclusions

The degree to which the decision aids improved decision performance appears to be dependent upon the individual's response toward risk. Use of the DDI display was significantly beneficial to those individuals who demonstrated a greater aversion to risk taking when placed in a high risk situation. When using the risk explicit display, these risk averse individuals showed no significant performance imporvement over the no-aid condition. Subjects who became less conservative or less risk averse under a high risk situation did not benefit by the use of these aids.

Although there was no evidence to support the contention that explicit risk information would enhance performance, the subjects in the investigation felt that risk information could very possibly be more important in

other tactical settings than were explored in this study. Thus, in the future development of decision analytic aids further consideration should be given the advisability of providing access to risk information upon request.

Additionally, the aspects of risk utilized in this investigation were but a subset of the possible dimensions. The failure of maximum subjective utility to completely account for the subjects' action selections suggests that other characteristics of the decision are operating and may very well represent some dimensions of risk which were not explored here.

Recommendations

1. Continue development of a maximum subjective expected utility (SEU) approach for decision aiding as in the Decisions and Designs prototype.

2. Identify decision making styles and the type of decision aiding approaches that benefit and hinder each.

3. Consider the use of group estimation procedures to obtain likelihood ratio estimates of increased reliability.

4. In a Bayesian approach such as the DDI prototype, the user of the decision aid should have the ability to update or change likelihood ratios to reflect conditional dependencies in the data.

5. The decision task in the DDI prototype should include an assessment of the probability that the enemy has changed its intent instead of assuming that all the data observed came from a steady generating state.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Problem

Decisions and Designs, Inc. (DDI), an Office of Naval Research (ONR) contractor, has developed a prototype decision analytic tool for use in the ONR Operational Decision Aids Project. In decision making, it is usually recommended that the decision maker (DM) select that alternative that will maximize his subjective expected utility (SEU) or outcome. Accordingly, the DDI decision aid displays the result of a decision analysis as a probability triangle (Brown, Peterson, Shawcross, & Ulvila, 1975), which continuously informs the DM as to the current probabilities of the states of the world (enemy intent) and indicates a recommended act which will maximize SEU given these probabilities. However, action recommendations based solely on this criterion may not always be appropriate for a Navy DM. Given the choice between two acts with approximately equal SEU, he might well prefer the act with the least perceived risk; that is, one in which he is somewhat more confident of the resultant outcome. He might even be willing to select an act that has lower SEU if it also involves lower risk. This risk is reflected in the range or variance of the possible outcomes as opposed to the mean of the outcomes as given by the SEU.

The DDI prototype does not provide for the perceived risk which may be associated with the various alternatives.

Background

The importance of risk considerations in addition to expected utility has been addressed in several studies (Allais, 1953; Coombs & Pruitt, 1960; Slovic, 1967; Slovic & Lichtenstein, 1968; Payne & Braunstein, 1971; Payne, 1975). Unfortunately, the relationships between risk and alternative preferences have been shown to be somewhat complicated. In fact, few attempts have been made to determine the nature of risk, the most formal being that by Pollatsek and Tversky (1970). However, these studies have suggested the properties which seem to reflect the risk associated with each act, such as variance, probabilities of the outcomes, maximum loss or regret, the range of outcomes, or some combination of these parameters (Rapoport & Wallsten, 1972).

The variance of the utilities associated with an act is a measure of the dispersion of the utilities for the outcomes that may result as a consequence of the act. Low variance for an act indicates that the utility for any outcome resulting from the act will be relatively close in value to its SEU; and high variance, that it may be quite different, relatively, from its SEU. Thus, different attitudes toward risk may possibly be based on preferences for variability of the utility of outcomes. By selecting a low variance act, a DM can be relatively confident that actual utility for the act will be close to its SEU.

Risk considerations can be incorporated within the SEU maximization framework by using a "π-BRLT" technique (Raiffa, 1968; Barclay, Brown, Chinnis, Kelly, & Peterson, 1973) which is a method for estimating an individual's utility for an outcome. The individual is asked to adjust the probability values of a basic reference lottery such that he would be indifferent to participating in the lottery or receiving the outcome for certain. Since the indifference point, as established in the context of a gamble, is that point where the individual could possibly obtain both more or less than the amount offered for certain, the expected value of the adjusted lottery is viewed as the risk-incorporating utility for the certain outcome. However, recent research (Slovic, 1975; Tversky, 1972) suggests that the results of procedures such as the "π-BRLT" method do not necessarily generalize to choice situations in a satisfactory manner.

Since little is known about the importance of perceived risk considerations in Navy operational decision making, the Navy Personnel Research and Development Center proposed an empirical study, utilizing the DDI prototype and a second decision aid developed by NAVPERSRANDCEN that incorporated possible risk factors, to investigate the significance of such factors in tactical decision making at the task force commander (TFC) level. The basic rationale for the study was not to examine risk per se but, rather, to determine if risk is a potent enough factor to warrant attention in the ONR decision aids.

Objective

As indicated, the objective of this study was to investigate the significance of perceived risk in decision making by a Navy TFC. To achieve this end, it was necessary (1) to implement, via computer, the DDI and NAVPERSRANDCEN decision aids, (2) to develop realistic tactical scenarios as a setting within which to compare the two aids, and (3) to secure subjects having detailed knowledge about Soviet tactical activity and experience in evaluating such activity.

To determine whether the availability of various "ingredients" of the SEU equation, in addition to those provided by the DDI prototype, would improve or degrade the performance of the DM, the Center studied the effect of the two displays under different conditions of perceived risk. Perceived risk was manipulated implicitly by varying the risk dimensions while maintaining the same type of decision scenario. Obviously, if risk considerations are found to be a major factor in naval decision making, it would be desirable to use a display that presents the necessary elements for the DM to assess the risk involved.

METHOD

This study compared the decision-aiding capabilities of two displays--the DDI triangle (risk implicit) and the Center developed bar graph (risk explicit)--in tactical scenarios under prevailing conditions of high or low risk. During a scenario, a decision maker (DM) could either refer to one of the displays or, in a control condition, to no aiding display. As data events occurred sequentially, the DM classified each event, entered this classification to the decision aid, observed the resultant integration of the entry, appraised enemy intent, and recommended an act in response on the basis of information available. The DM used either one of the decision aiding displays or no aid during different blocks of the experiment, with each DM serving as his own control and with the various conditions counterbalanced. Each scenario presented to the DM was designated as either a high or low risk condition.

Subjects

The Center obtained formal consent from the Chief of Naval Education and Training (CNET) for the cooperation of the Fleet Combat Direction Systems Training Center, Pacific (FCDSTCP) in this project. FCDSTCP is the West Coast site of the Navy's Tactical Action Officer (TAO) school, which trains officers in analysis of and response to enemy tactical activity. Twelve FCDSTCP naval officers who serve as TAO course instructors participated as subjects.

Scenarios

Scenarios developed were based on the ONRODA warfare scenario (Payne & Rowney, 1975), and amplified by appropriate risk-manipulating scene setters. To ensure these scenarios were based upon up-to-date intelligence about enemy weapons and tactical employment, the third author attended a 1-week Multi-Threat Overview course conducted by FCDSTCP. Also, current Navy intelligence publications were extensively researched and consultations were held with FCDSTCP staff personnel. As a result 18 realistic tactical scenarios were constructed, nine of which were actually used in the experiment. The scenarios unfold in an open-ocean environment and involve transit of a U.S. task force (the Blue force), composed of a single aircraft carrier CV and three destroyer escorts, toward ONRODA Island. The mission of this task force is to arrive in the ONRODA area to provide a continuous capability for projecting strikes onto ONRODA Island and the Greyhawk-held areas in Grey (Payne & Rowney, 1975). An integral part of this mission is to conserve task force assets as much as operationally feasible during the transit so as to arrive in the ONRODA area with maximum strike capability. However, during its move to station, the task force is subject to a full spectrum of possible Red tactical activity--ranging from routine surveillance activity to harassment of the U.S. force to actual attack on the task force. These various Red intents are defined as follows:

1. ROUTINE—Red intends to engage in only his routine (as understood by the task force commander) surveillance and training activities during U.S. task force transit. There is no intent to prevent, by harassment, the U.S. force from carrying out its mission nor any intent to attack the U.S. task force.

2. HARASS--Red intends, in some manner short of actual attack, to prevent the U.S. task force from carrying out its assigned mission in a timely manner or intends to cause expenditure of task force assets above routine level.

3. ATTACK--Red intends to attack the U.S. task force.

As the scenario unfolded, the DM was required to decide the intent of each Red activity, as defined above, and then decide upon an appropriate response by his own force, weighed against the risk of degrading the force's ability to eventually carry out its original mission. His three choices of action are defined as follows:

1. ROUTINE—Maintain only that readiness posture and expend only those task force assets during the transit appropriate for a Red intent of routine operations so as to arrive in the ONRODA area on time and with maximum assets available.

2. STAGE—Operate at a readiness posture and/or expend task force assets at some level above routine but short of attack.

3. ATTACK--Attack the Red forces.

The rules of engagement (ROE) governing the task force commander's actions in the scenarios were as shown below:

WHEN CERTAIN[a] THAT RED INTENT IS	TAKE TASK FORCE ACTION
ROUTINE	ROUTINE
HARASS	STAGE
ATTACK	ATTACK[b]

[a]In cases less than certainty, take that action you judge to be most appropriate.

[b]You may shoot first if you feel you have strong enough indication that Red intends to attack.

Risk Conditions

Scenarios were presented against either a high-risk or a low-risk background for decision making.

For the high-risk background, referred to as the "one CV" case, subjects were told that the task force for which they were functioning as TFC was the only one available to carry out the ONRODA mission. Therefore, if it failed to reach the ONRODA area on schedule or reached there with degraded assets, the mission could not be fully accomplished.

For the low-risk background, referred to as the "three CV" case, subjects were told to assume that there were two additional U.S. task forces enroute to ONRODA. Although the geographical location of these task forces precluded the DM from interacting with them during the transit, there was a possibility that, upon their arrival in the ONRODA area, they could assume some or all of the mission assigned to the subject's own task force if it failed to arrive on schedule or arrived with degraded assets.

Decision Aiding Conditions

DDI Triangle

The DDI decision aid is described in detail in Brown, Peterson, Shawcross, and Ulvila (1975). Rather than reproduce the aid in its entirety for this study, NAVPERSRANDCEN incorporated only those features that were necessary to study risk effects. Utilization of the NAVPERSRANDCEN version of the DDI aid required classification of a scenario data event in terms of its threat to the task force. The likelihoods associated with the designated level of threat were used by the decision aid to perform a Bayesian revision of the prior probabilities that each of three hypotheses was true. A decision "bug" moved about in a triangular probability space according to the posterior probabilities computed with each data indicator designated to have occurred. The triangular probability space was delineated into "action areas," which were determined by a utility matrix appropriate for the decision to be made. This matrix reflected the DM's valuation for the resultant outcomes of his action alternatives, based upon the condition of each hypothesized state of the world being true. Based upon the utility matrix, the action areas simply represented those locations in the triangular probability space for which a particular action would have the greatest SEU. Thus, the location of the "bug" in any action area identified that action as the aid's recommendation, based upon the DM's utilities and the data events that had occurred. Illustrations of sequences of data events and how they were displayed in the Center version of the DDI aid is given in Figures 1 through 3. In these figures, "●" marks the location of the initial prior probabilities, "N" represents the newest set of posterior probabilities, and "O" represents the second most recent set of posterior probabilities. Other items appearing in these figures are described in the "Procedure" section.

SCENARIO 1 Page 1

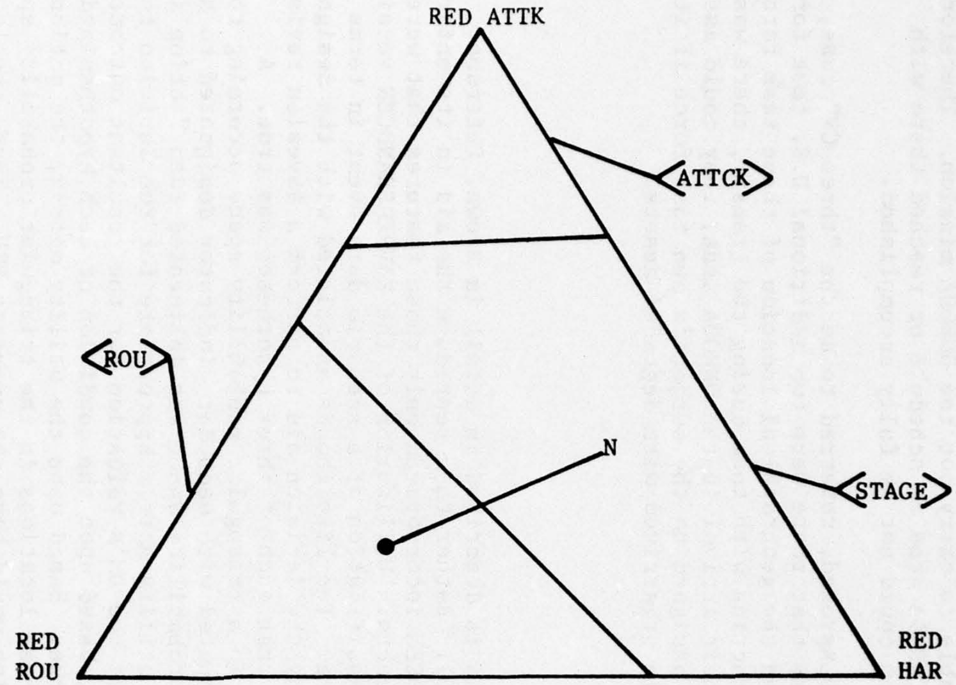
ENTER DATA CLASS ID E1

LIKELIHOOD CHANGE (N-NONE,
T-TEMP OR P-PERM) N

ENEMYS PROBABLE INTENT?
R-ROU, H-HARASS,
OR A-ATTACK H

WHICH ACTION WILL YOU TAKE?
R-ROU, S-STAGE
OR A-ATTACK S

HOW CONFIDENT ARE YOU
IN THIS DECISION? 4



DATA CLASS	LIKELIHOODS			PROBABILITIES		
	ROU	HAR	ATTK	ROU	HAR	ATTK
				PRIOR PROBABILITIES		
E1	1	4	4	50	30	20
				20	48	32

Figure 1. DDI Triangle Display (Trial 1).

SCENARIO 1 PAGE 2

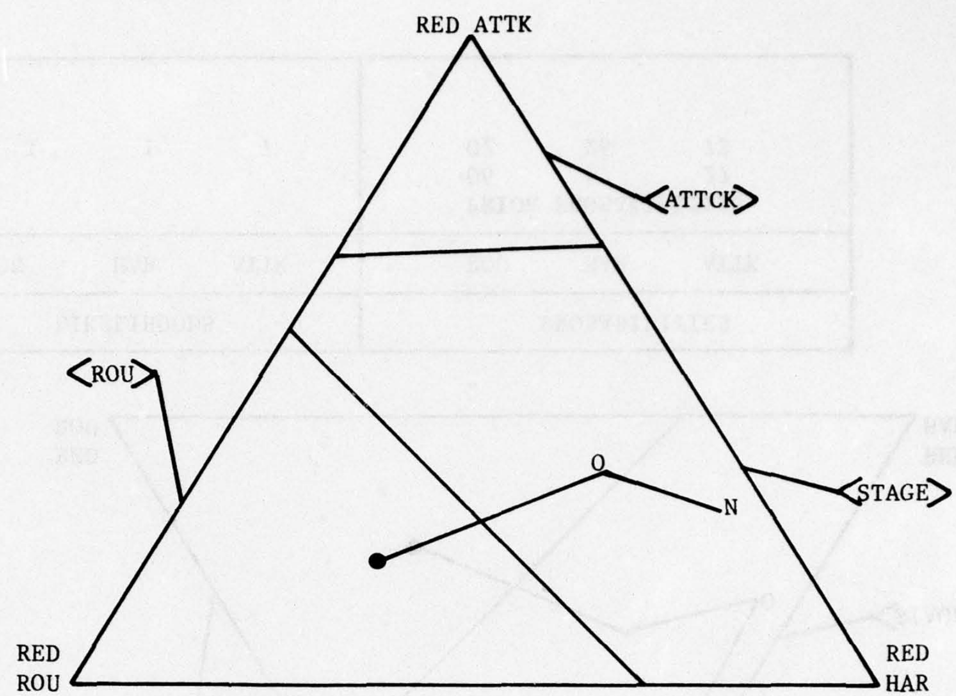
ENTER DATA CLASS ID C2

LIKELIHOOD CHANGE (N-NONE,
T-TEMP OR P-PERM) N

ENEMYS PROBABLE INTENT?
R-ROU, H-HARASS,
OR A-ATTACK H

WHICH ACTION WILL YOU TAKE?
R-ROU, S-STAGE,
OR A-ATTACK S

HOW CONFIDENT ARE YOU
IN THIS DECISION? 4



DATA CLASS	LIKELIHOODS			PROBABILITIES		
	ROU	HAR	ATTK	ROU	HAR	ATTK
				PRIOR PROBABILITIES		
				20	48	32
C2	1	5	3	06	67	27

Figure 2. DDI Triangle Display (Trial 2).

SCENARIO 1 PAGE 3

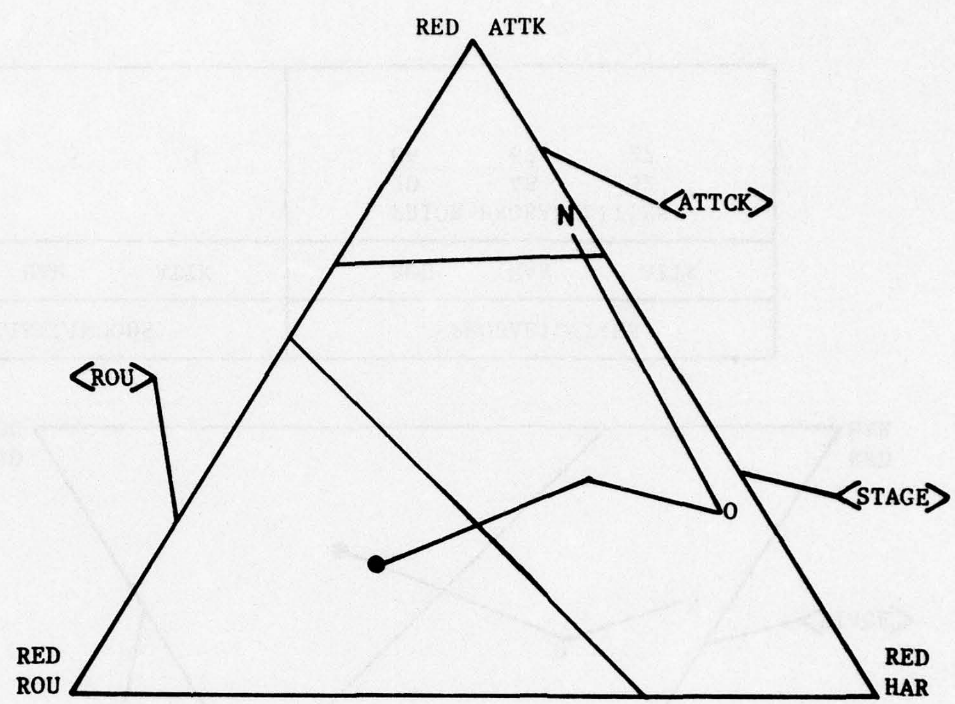
ENTER DATA CLASS ID M1

LIKELIHOOD CHANGE (N-NONE,
T-TEMP OR P-PERM) N

ENEMYS PROBABLE INTENT?
R-ROU, H-HARASS,
OR A-ATTACK A

WHICH ACTION WILL YOU TAKE?
R-ROU, S-STAGE,
OR A-ATTACK A

HOW CONFIDENT ARE YOU
IN THIS DECISION? 5



DATA CLASS	LIKELIHOODS			PROBABILITIES		
	ROU	HAR	ATTK	ROU	HAR	ATTK
				PRIOR PROBABILITIES		
				06	67	27
M1	1	1	7	02	26	72

Figure 3. DDI Triangle Display (Trial 3).

NAVPERSRANDCEN Bar Graph

The basic information contained in the DDI triangle was provided by the NAVPERSRANDCEN bar graph, plus some additional elements. Most importantly, the graphical display was designed to more directly reflect utilities and probabilities of the various possible outcomes. For each outcome, utilities were displayed explicitly as a bar located along a utility scale provided for each action alternative. The heights of the bars reflected the posterior probabilities of the outcomes associated with each act. By showing the actual utilities and probabilities of outcomes in the display, it was possible to provide risk-related information explicitly at each decision opportunity. To ensure that the DM had the same information that he had available in the DDI display, a small triangular indicator was placed along the utility scale for each act to indicate the SEU associated with that act. The DM, therefore, could make a decision based not only upon a criterion of SEU maximization but also upon the relative utilities and probabilities of the outcomes within each act (thereby providing the DM the information to assess risk if he chose). Figures 4 through 6 illustrate the NAVPERSRANDCEN bar graph display for the same data events that were used in illustrating implementation of the DDI decision aid.

No Aid Condition

During the control condition, the DM had to perform the same data classification tasks that were required using one of the aids described above but with no decision-aiding device available.

Design

The study basically consisted of six possible conditions of aiding combinations.

1. DDI triangle--high risk.

2. DDI triangle--low risk.

3. NAVPERSRANDCEN bar graph--high risk.

4. NAVPERSRANDCEN bar graph--low risk.

5. No aid--high risk.

6. No aid--low risk.

Although each subject participated in only three of the six combinations, he did participate in all three aiding conditions and in both risk conditions at least once. The order in which subjects participated in the various conditions was counterbalanced over subjects. The assignment of subjects to conditions is shown in Table 1.

SCENARIO 1 PAGE 1

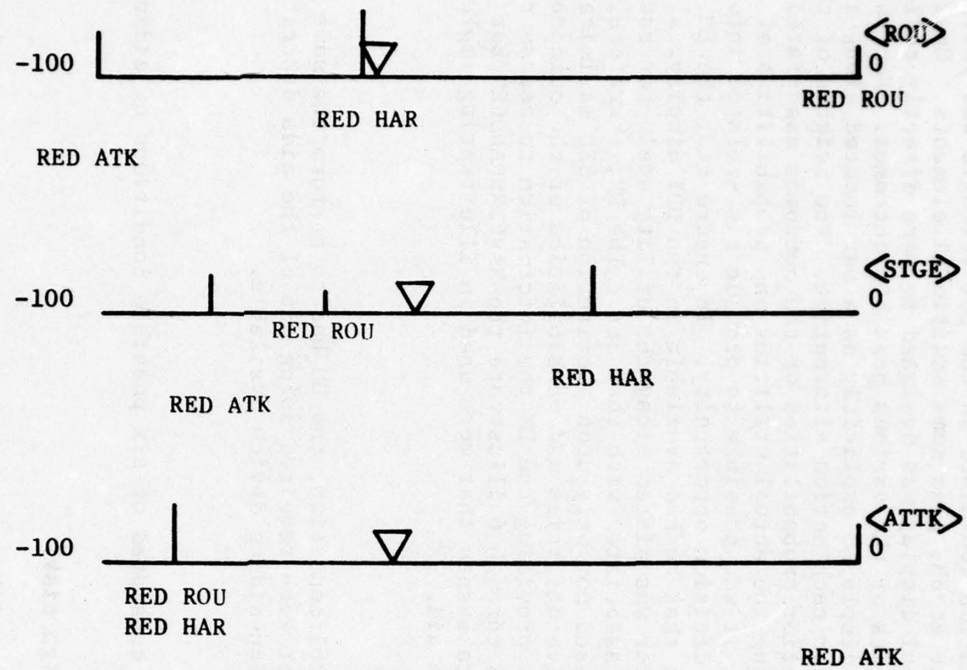
ENTER DATA CLASS E1

LIKELIHOODS CHANGE
(N-FOR NONE, T-FOR TEMP
OR P-FOR PERM) N

ENEMYS PROBABLE INTENT?
TYPE R-ROU, H-HARASS
OR A-ATTACK H

WHICH ACTION WILL YOU
TAKE? TYPE R-ROU,
S-STAGE OR A-ATTACK S

HOW CONFIDENT ARE YOU
IN THIS DECISION? 4



DATA CLASS	LIKELIHOODS			PROBABILITIES		
	ROU	HAR	ATTK	ROU	HAR	ATTK
				PRIOR PROBABILITIES		
				50	30	20
E1	1	4	4	20	48	32

Figure 4. NAVPERSRANDCEN Bar Graph Display (Trial 1).

SCENARIO 1 PAGE 2

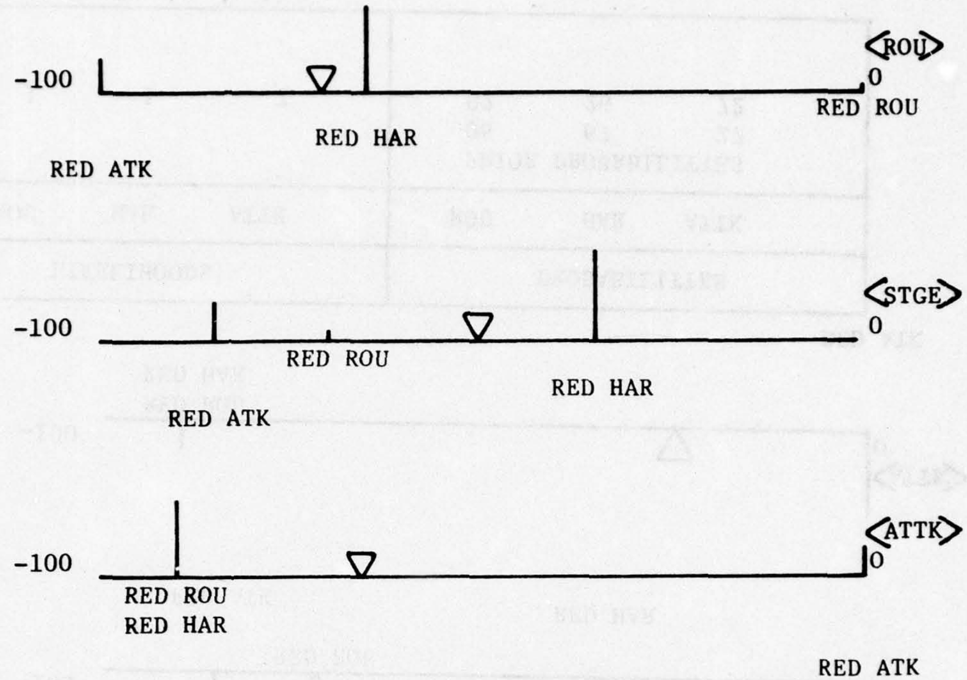
ENTER DATA CLASS C2

LIKELIHOODS CHANGE
(N-FOR NONE, T-FOR TEMP
OR P-FOR PERM) N

ENEMYS PROBABLE INTENT?
TYPE R-ROU, H-HARASS
OR A-ATTACK H

WHICH ACTION WILL YOU
TAKE? TYPE R-ROU,
S-STAGE OR A-ATTACK S

HOW CONFIDENT ARE YOU
IN THIS DECISION? 5



DATA CLASS	LIKELIHOODS			PROBABILITIES		
	ROU	HAR	ATTK	ROU	HAR	ATTK
				PRIOR PROBABILITIES		
				20	48	32
C2	1	5	3	06	67	27

Figure 5. NAVPERSRANDCEN Bar Graph Display (Trial 2).

SCENARIO 1 PAGE 3

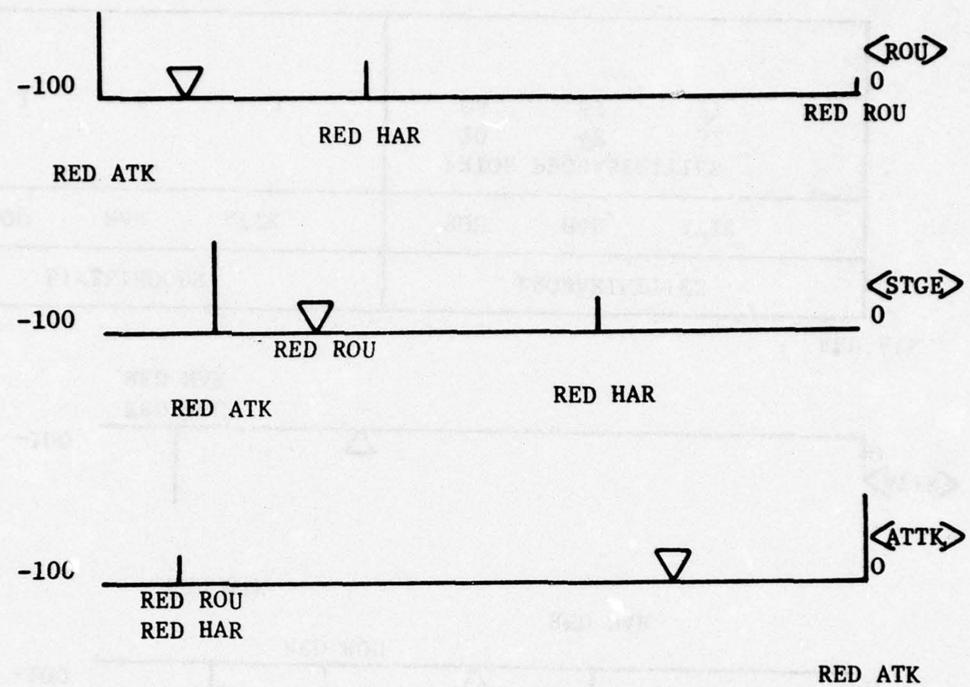
ENTER DATA CLASS M1

LIEKLIHOODS CHANGE
(N-FOR NONE, T-FOR TEMP
OR P-FOR PERM) N

ENEMYS PROBABLE INTENT?
TYPE R-ROU, H-HARASS
OR A-ATTACK A

WHICH ACTION WILL YOU
TAKE? TYPE R-ROU,
S-STAGE OR A-ATTACK A

HOW CONFIDENT ARE YOU
IN THIS DECISION? 5



DATA CLASS	LIKELIHOODS			PROBABILITIES		
	ROU	HAR	ATTK	ROU	HAR	ATTK
				PRIOR PROBABILITIES		
				06	67	27
M1	1	1	7	02	26	72

Figure 6. NAVPERSRANDCEN Bar Graph Display (Trial 3).

Table 1

Experimental Design

Subject	DDI Triangle		NAVPERSRANDCEN Bar Graph		No Aid	
	High Risk	Low Risk	High Risk	Low Risk	High Risk	Low Risk
S_1	X		X			X
S_2	X			X	X	
S_3		X		X	X	
S_4		X	X			X
S_5	X		X			X
S_6	X			X	X	
S_7		X		X	X	
S_8		X	X			X
S_9	X		X			X
S_{10}	X			X	X	
S_{11}		X		X	X	
S_{12}		X	X			X

Two scenarios of different types (routine, stage, or attack) were presented to the subject within each experimental condition in which he participated. Thus, a subject was presented with six different scenarios. The scenarios were counterbalanced for type so that the subject saw each type exactly twice--but never twice in the same condition.

Following the three experimental conditions, a fourth condition was administered which was matched to the condition in which the subject was given the DDI triangle. For example, if the subject originally saw the DDI triangle under the "high risk" condition, he was again presented with the DDI triangle under the high risk condition. However, in the extra condition, the boundaries of the action areas in the triangle were determined by the risk-incorporating utility matrices, which were, in turn, estimated by a method of theoretical extrapolation discussed below. The scenarios presented during this additional condition, although different from the first six, were also selected to match the enemy intent when the subject originally saw the DDI triangle.

Stimulus Material

The computer facility used in this study was not cleared to utilize classified information. Thus, the scenarios, which were based upon a great deal of SECRET material could not be presented by a computer-generated display but were confined to printed SECRET copy. Each data occurrence was presented on a separate page that contained (1) printed narrative along with its concomitant status board information and (2) a group of classifications, one of which was to be chosen by the DM as that most descriptive of the data event presented.

Each scenario consisted of 20 such events combined to form a small folder, the pages of which are successively examined as the DM progressed through the scenario. At any page in the scenario, the status boards contained on that page showed a summary of the data events occurring up until that point. Appendix A provides an example of a scenario, purged of classified material, used in the study.

Questionnaire

A short questionnaire (Appendix B) was administered to each subject after he completed the experimental sessions. The questionnaire consisted of several items to which the subject gave responses along a five-point Likert scale. Some items were intended to measure the individual's attitude toward using computer-based decision aids, in general, and the decision aids presented during the experiment, in particular; and others, to assess the adequacy of the indoctrination briefing and to check on the attitudinal effect of the risk manipulation. Additional information was gathered to provide an experience profile of the subject population.

Apparatus

The two decision aids were implemented on the Center's Digital Equipment Corporation PDP-12 computer and interfaced Tektronix 4006-1 graphics terminal using a locally modified version of the SP-12 programming language. A subject used the terminal to input information into and to receive information from the aid. The computer was also used to systematically query the DM and to record information during a scenario's evolvement and the progression of the DM through the scenario.

Procedure

A project briefing, lasting from 3 to 3 1/2 hours, was given to subjects, in groups of three at a time. Following a general description of the ONR decision-aiding project and objectives, it was stressed that aids to be utilized by subjects in this experiment were prototypic in form and constituted only a small portion of the entire ONR decision-aiding package.

The briefing continued with a general introduction to the ONRODA scenario and a description of the subject's role as commander of a U.S. task force enroute to the ONRODA area. Differences between the one CV and three CV cases were detailed. Potential enemy activity during the transit was explained to come only from Red, who could be taken to be the Soviets. The requirement for the TFC to determine both Red intent and an appropriate Blue task force response, defined as in the "Scenarios" section above, was described.

The rules of engagement included a provision for the Blue force to shoot first, which is exactly opposite to rules under which our subjects have operated in real world tactical situations. Thus, to justify this action, subjects were told to assume that, in the recent past, a U.S. destroyer on an intelligence-gathering mission off the coast of a small Red ally was hit and sunk by an antiship cruise missile. This sinking occurred in spite of numerous electronic indications aboard the destroyer that a missile attack was imminent. The Navy, in response to the resulting Congressional criticism, changed the old "don't fire unless fired upon" rule to allow a commander to fire first if he feels there is strong enough indication an enemy intends to attack.

Without this provision for firing first, a fair exercise of the decision aids could not have been achieved since a subject would not have decided to attack unless fired upon. Obviously, at this point, the DM need not refer to the aids studied in this experiment.

The briefing continued with a discussion of the inputs required to the system's mathematical model. Likelihood ratios for threat categories within generic data classes constituted the first of these inputs. After describing the almost overwhelming problem an unaided human has in interpreting the mass of data arriving at the task force command center, the importance of anticipating data and its implication concerning Red intent

was stressed. Rapid processing of such data in a manner consistent with the laws of probability to achieve reassessment of Red intent can be done with computer aids, but they require, as inputs, numerical expressions of subjective understandings of data implications. The concept of a likelihood ratio was then introduced with specific numerical examples based upon the briefer's understanding of the world. Subjects were then given a list (Appendix C) of the generic data classes (Red threat indicators) used in the experiment and requested to supply likelihoods for this list that best captured their subjective estimate that each data classification might be observed, given that any particular hypothesis about the enemy's intent be true. As a starting point, the list contained likelihoods provided by the briefer. It had been determined in planning the experiment that an individual previously unfamiliar with the likelihood concept was more comfortable in making such estimates if an example of values was provided as a starting point. A subject was allowed as much time as necessary to develop his likelihood set, with 30 minutes being approximately the average time taken. Likelihoods were estimated by first selecting percentages within each intent column which the subject thought appropriate and which added to 100 percent. Then ratios of these percentages across the various enemy intents (the likelihood ratios) were checked and adjusted to capture the subject's feelings. The process was repeated until a set of numbers had finally been obtained such that percentages within columns added to 100 percent and likelihoods across columns expressed the subject's understanding of the relation between data events and Red intent.

The briefing continued with a discussion of how one might rank order the set of Blue act and Red intent combinations on the basis of one combination seeming, all things considered, to be better than another. The briefer's orderings, for both the one CV and three CV cases, were supplied as examples, and then each subject was asked to determine his own orderings. Subjects were then asked to supply numerical values, on a scale of 0 to -100, to these orderings, with 0 being at the "best" end of the scale and -100 at the "worst." It was stressed that value sets for the one CV and three CV cases were not independent. If, for instance, a value assigned to an act and intent combination in the three CV case fell between two values assigned in the one CV case, the subject was to verify that this was consistent with his subjective ordering of the three act and intent combinations involved. The result of this numerical scaling was two utility matrices, one for each of the risk cases.

At this point in the briefing, a π-BRLT-like theoretical extrapolation technique was employed to extract two additional matrices incorporating the DM's risk preference in the one CV and three CV cases.

This involved determining the value of an equal (50-50) gamble between the "best" and "worst" outcome combinations, as determined in the above rank ordering. The participant was asked to locate a value on the 0 to -100 scale. This value was to be selected so that the participant would be indifferent between receiving an outcome with that value for certain or receiving an outcome determined by the equal probability gamble between the best and the worst outcomes. The value so determined was used to solve for the exponent Θ in the power function

$$Y = f(X) = aX^{\Theta},$$

where $\underline{a}$ is a constant selected so that the function ranges between 0 and -2000, $\underline{Y}$ = -1000 at the point where $\underline{X}$ = value of indifference. Under the assumptions of substitutability and indifference, as well as the psychometric power function itself, a curve was produced which roughly described the participant's utility function and incorporated some aspect of the individual's attitude toward a risky choice. The function was used to transform values in the original matrix to form a risk-incorporating utility matrix. An indifference value estimation and the subsequent matrix transformation were performed for both the one CV case and the three CV case.

The concept of an act's expected utility was then introduced via a specific numerical example utilizing utilities drawn from the briefer's one CV utility table and a particular probability triplet for Red intent. Special care was taken to explain that expected utility is one dimension decision makers often take into account in uncertain situations, but it is not necessarily the only one. As an example, it was pointed out that Las Vegas casinos are willing to base their operations on expected value, whereas the thousands of players who visit these casinos each year must be considering dimensions in addition to expected value, since the expected values of games played favor the casinos.

After careful description of how each aid--triangle and bar graph--presents concepts developed in the brief, subjects were given a "hands-on" introduction to the two aids at NAVPERSRANDCEN's PDP-12 computer facility. This concluded the experiment's briefing portion.

Subjects returned on an individual basis, usually within 48 hours of the briefing, for the experiment's data-gathering phase. After a brief review of his required tasks, the DM was assigned two scenarios under a particular risk condition (one CV or three CV) and asked to proceed through the scenarios utilizing one of the decision aids (triangle or bar graph) or no aid. When the two scenarios were completed, the subject was offered the opportunity for a brief rest break, and then the process was repeated until the subject had seen triangle, bar graph, and no-aid conditions. Decision aids were provided with the subject's conditional likelihoods and appropriate non-π-BRLT utility matrix elicited previously. When this portion of the data gathering was concluded, a subject was run through two additional scenarios utilizing the triangle with a π-BRLT matrix of risk-incorporating utilities appropriate for the risk condition assigned.

At the beginning of each scenario, the DM was provided a summary of own and enemy force activity along with, when the triangle or bar graph was to be used, an appropriate prior probability assessment of Red intent. The DM then turned to the first page of the scenario folder, read the report describing enemy activity, determined which threat classification best identified the data event, and entered the classification identification into the terminal. If a decision aid was being used, the DM's own predetermined likelihoods associated with the data class were returned on the display, and the DM was given an opportunity to adjust these likelihoods

before the aid used them to revise prior probabilities about enemy's intent. If he decided to make a likelihood change, it could either be a permanent or a temporary change. With a permanent change, the new set of likelihoods entered replaced the predetermined likelihoods until another permanent change was made to the set or until the end of the scenario, whichever occurred first. At the conclusion of a scenario, the predetermined likelihoods were once again in effect. With a temporary likelihood change, the new set of likelihoods replaced the existing set for just that particular page of the scenario. Upon revision, the graphic display was updated and posterior probabilities shown to reflect the data event's effect.

The DM then had an opportunity to examine the display and make an estimate, based upon all available information, as to enemy's intent. The DM was then asked for an action recommendation for his own force. He then had to rank on a scale from 1 ("not very confident") to 5 ("extremely confident") how confident he was in his decisions about threat assessment and act response. Once this was done, a signal was given for the DM to proceed to the second data event. The process was repeated until all 20 data events of the scenario had been presented.

When the subject had completed eight scenarios, a second π-BRLT technique was employed to once again estimate utilities that reflected the individual's attitude toward risk. This was accomplished by having the individual adjust the probability components of a two-outcome gamble so that he would be indifferent to receiving the outcome determined by this gamble and receiving the outcome determined by a two-outcome reference gamble. The reference gamble involved a 99 percent chance of receiving what the individual had judged to be the best Blue act and Red intent outcome combination and a 1 percent chance of receiving the worst outcome. The gambles that the participant adjusted involved a π percent chance of receiving the best outcome and a $(100-\pi)$ percent chance of receiving one of the remaining outcomes. The participant estimated a π-indifference value for each of the remaining act and intent combinations between the rank-ordered "best" and "worst." By this procedure, an equivalence was established which implicitly determined the subject's utility for each of the outcomes (Raiffa, 1968). This second estimation of risk-incorporating utilities, though a procedure more directly derivable from the utility axioms of von Neumann and Morganstern (1953) than the first, was more difficult to implement within the framework of the subject matter and experimental task of our study. The first procedure required the subject to estimate only a single indifference value--an important consideration when time is of the essence. When time permitted, the second procedure was done as a corroborating check of the estimation procedure.

Finally, the subject's participation concluded with administration of the questionnaire which recorded his reactions to the experiment.

The software written for the three experimental conditions stored all the necessary information on magnetic tape for reconstructing the subject's display at any point in the scenario. These data included scenario and data identification, the subject's classification of the data, any modification of the likelihoods he introduced, his assessment of enemy intent, the act that he selected, and the confidence ranking he gave his decision. These data were transferred to a master tape and used to produce a "hard copy" summary at the end of each session.

RESULTS AND DISCUSSION

Issues of Risk

The central purpose of this study was to investigate the significance of perceived risk in decision making by the TFC. The hypothesis was tested by making certain dimensions of the risk associated with each alternative in a decision more explicit. If the decision maker utilizes this added information in a way that suggests that he is concerned with risk, then risk is a factor in his decision.

Risk as an Independent Variable

The attempt to increase perceived risk by varying the number of CV's composing the task force met with limited success. This was evidenced by the fact that subjects disagreed with the 4th questionnaire item, which stated that it was more important to make the correct decision when there were three CV's present rather than one CV. This statement was in accord with our intention that the one CV task force situation be perceived as one of higher risk and therefore requiring greater need for the correct decision. As indicated previously the subjects reported their attitude toward each item by choosing a response along a five-point Likert scale in which "1" indicated strong disagreement with the statement and "5," strong agreement. The median response for the 4th item was "2," and was given by seven out of the twelve subjects. However, when the risk estimation procedures were used to assess utilities in a lottery or gaming situation, the resulting utility functions for the high and low risk conditions were quite inconsistent. The value of the exponent Θ in the power function, $Y = aX^{\Theta}$, which describes the utility function is an index of the subject's risk preference. Figure 7 illustrates the curve. If Θ is described by the expression for various values of Θ greater than 1, then the utility function is convex in quadrant III and indicates a preference toward risk. When the curves are convex, an outcome of -50 (i.e., half the range possible) on the abscissa is associated with an amount that is less than half the range possible on the ordinate. If Θ is less than 1, the curve is concave and indicates an aversion to risk. When the curves are concave, an outcome of -50 on the abscissa is associated with an amount that is more than half the range possible on the ordinate. Table 2 presents the estimated Θ's for the subjects under both risk conditions. These values were determined by fitting the power expression through the single point obtained from the subject during the procedure for estimating risk incorporating utilities. By using Θ as an index of attitude toward risk, it was readily apparent that large individual differences existed in the manner in which the subjects were affected by the risk manipulation. Seven of the twelve subjects were more risk averse under the high risk condition. The remaining five subjects were more risk preferenced under the high risk condition.

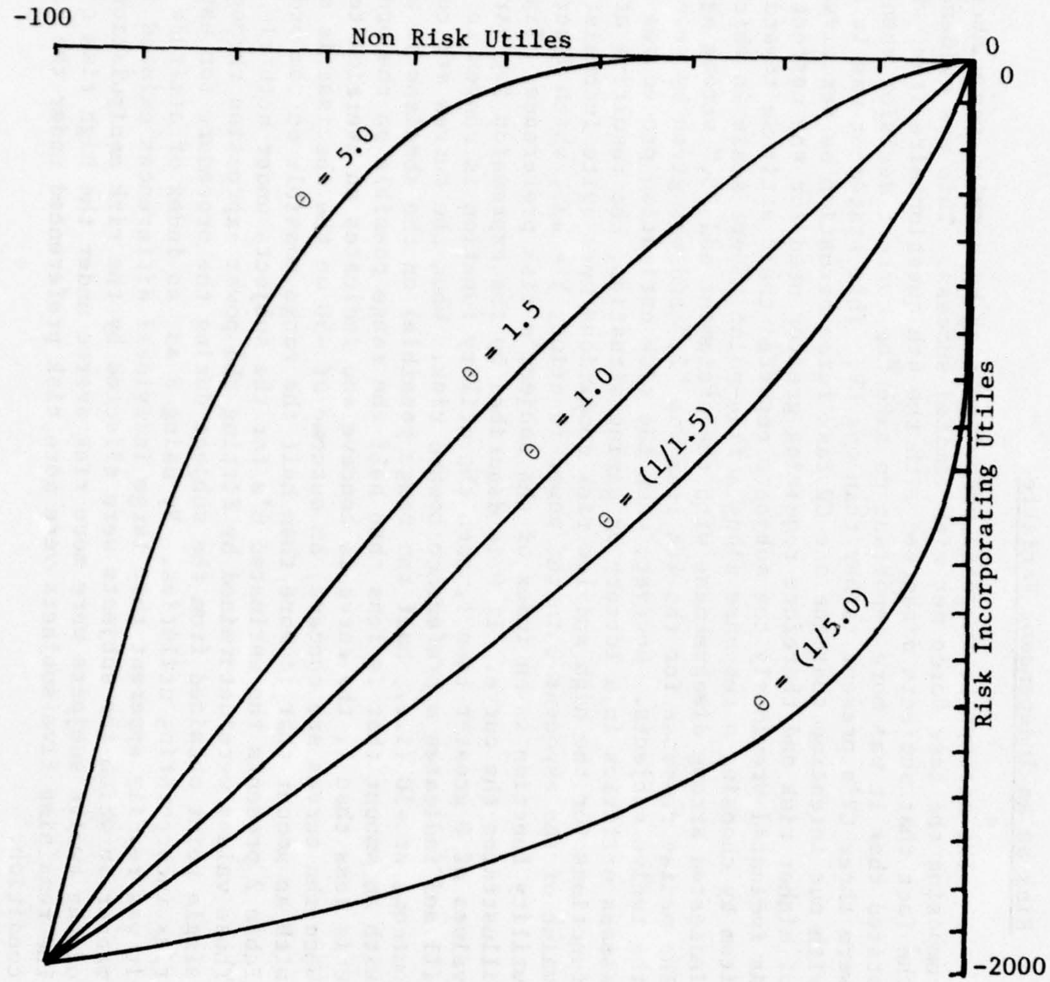


Figure 7. Risk incorporating Utility Function ($Y = aX^{\Theta}$)

Table 2

Estimated Θ for the Risk-Incorporating Utility Function

Subject	High Risk (1CV)	Low Risk (3CV)
1[a]	4.60	1.16
2[b]	.33	2.13
3[b]	1.36	2.27
4[b]	.29	4.92
5[a]	13.51	.30
6[a]	13.51	.17
7[b]	.87	1.98
8[b]	1.60	2.41
9[b]	1.16	6.58
10[a]	2.41	1.00
11[a]	3.49	2.41
12[b]	.72	.97

[a]Classified as risk preferenced

[b]Classified as risk averse

In order to assess the behavioral effects of the risk manipulation, it was necessary to establish a performance measure. To evaluate the performance of a subject and/or aiding condition, a so-called "batting average" or "outcome" score was used. The manner in which this score was determined is given in detail in Appendix D. Suffice it to say at this point that the performance score reflected the ability of the subject to discern the enemy intent in a timely fashion.

The subjects' data were analyzed by a balanced incomplete block ANOVA. The analysis was first conducted upon the performance scores computed by using each individual's own non-risk incorporating utility matrix. A subject's score in each condition was taken to be the sum of his scores on all the scenarios seen under that condition. Considering all the subjects combined, no significant difference was found among the performances using any of the aids and under any risk condition ($F = .147$; $df = 5, 19$). The performance scores are given in terms of a negative score because the utilities were measured as relative costs for each outcome. The mean performance scores for each condition are given in Table 3. Better performance is given as a less negative score. The means for each condition are also given in Table 3. Although the differences are not reliable, it was surprising to see that performance using the aids was lower than the performance in the no-aid control. However, if the subjects were grouped on the basis of whether their Θ indicated that they were more risk averse or risk preferenced under the high risk condition, a look at the subgroup means reveals an interesting result. In order to test the effect of the aiding conditions upon performance for the risk averse subgroup, a Friedman two-way analysis of variance of ranks was performed. The results showed the overall difference between aiding conditions to be slight ($\chi^2_{r,\ 2df} = 4.57$; $p \leq .112$). A post hoc comparison of the treatments against the control showed the performance using the DDI display to be significantly ($r^* = 8$; $p \leq .05$) better than the control. Performance using the NAVPERSRANDCEN display was somewhere between and not significantly different from the control. The risk preferenced subjects performed best under the control condition, surpassing the performance of the risk averse subjects at their best. However, the overall difference was not significant ($\chi^2_{r,\ 2df} = 1.60$; $p \leq .522$) and a comparison of the treatment means with the control showed no significant differences either. These results indicate that only risk averse individuals benefited from information supplied by the DDI aid. The findings suggest that (1) the hypothesis that performance can be improved by making certain aspects of risk explicit is not true and (2) risk preferenced individuals may actually have been slightly hindered by the presence of an aid. The question arises as to why the same information made available to two groups would benefit the group which wishes to avoid risk and yet would hinder the group which prefers risk. One speculative, but possible, explanation arises from the demand characteristics of the study. The briefing placed considerable emphasis upon the role of SEU in selecting from amongst alternatives. The aids, as designed, prominently display SEU information. If SEU information is not normally a major factor in the decision process, an attempt to incorporate it could be disruptive. To test this possibility, another performance score was calculated for the two subgroups. Instead of scoring the act that the

subject actually selected, we scored the act which the aid recommended on each trial. In effect, this was a scoring of the system's performance. This scoring was done only for the DDI triangle display because it was the only display in which a specific act recommendation was made. The result from this scoring of the aid's recommendation is shown in Table 3 alongside scores based on the actual selected act. Note that the mean "aid alone" performance for the risk preferenced group is considerably worse than the mean performance for the individual using the aid ("aid and individual"). This difference is considerably larger than the corresponding difference for the risk averse group. The indication here is that individuals in the risk preferenced group were introducing some factor or factors other than maximum SEU into the decision process and were doing it to a greater extent than the individuals in the risk averse group. Whatever these factors are, they may ordinarily have been these individuals' primary factors for selecting acts. In the control condition, they were not "burdened" by the display along with its recommendation and, consequently, performed better.

Since the differences shown in Table 3 could be capitalizing upon the differences in the utility matrices given by the individuals, the analysis was repeated using an average utility matrix. A matrix consisting of the mean non-risk incorporating utilities for each act/intent outcome was determined. This average matrix was then used to score both the performance of the individuals (using the aids) and the performance of the aid alone. The means of this are given in Table 4. Analyses of these scores reveal essentially the same scoring results and implications as the analyses of the scores in Table 3.

Table 3

Mean Performance Scores by Conditions

Item		DDI High	DDI Low	DDI Combined	NAVPERSRANDCEN Bar Graph High	NAVPERSRANDCEN Bar Graph Low	NAVPERSRANDCEN Bar Graph Combined	Control High	Control Low	Control Combined
I.	All Subjects	-68.6	-64.3	-66.4	-65.27	-56.4	-60.8	-57.8	-61.47	-59.63
	Aid Alone	-91.9	-67.8	-79.9						
II.	Risk Averse Subgroup	-57.6	-54.9	-55.7	-67.0	-48.8	-59.2	-82.0	-80.2	-81.0
	Aid Alone	-72.0	-60.0	-63.4						
III.	Risk Preferenced Subgroup	-74.1	-110.9	-81.4	-61.8	-64.0	-63.1	-33.7	-24.0	-29.8
	Aid Alone	-101.8	-107.0	-102.9						

Note: Conditions were scored by using each individuals' own utility matrix, less negative score reflects better performance.

Table 4

Mean Performance Scores by Condition

Item		DDI			NAVPERSRANDCEN Bar Graph			Control		
		High	Low	Combined	High	Low	Combined	High	Low	Combined
I.	All Subjects	-61.2	-53.3	-57.2	-72.0	-61.2	-66.6	-58.5	-88.3	-73.4
	Aid Alone	-87.5	-60.1	-73.8						
II.	Risk Averse Subgroup	-57.1	-43.9	-47.6	-75.5	-51.5	-65.2	-69.6	-109.8	-92.6
	Aid Alone	-69.3	-52.0	-57.0						
III.	Risk Preferenced Subgroup	-63.2	-100.7	-70.7	-64.9	-70.8	-68.5	-47.4	-45.2	-46.6
	Aid Alone	-96.5	-100.3	-97.3						

Note: Condition scored by using the average utility matrix.

The Dimensions of Choice

By making certain aspects of the action alternatives more explicit in the NAVPERSRANDCEN bar graph display, we had anticipated a decline in the frequency of times that the act the subject selected corresponded with the act which had the maximum SEU. The percentage of times that a subject agreed with the maximum SEU act is given in Table 5. As might be expected, the frequencies were higher for the conditions in which the aids were present. Contrary to our expectations, the frequency of subject agreement with the maximum SEU was higher for the bar graph condition than for the DDI triangle condition. An interaction between decision aids and risk conditions is suggested by the data. When using the DDI triangle, subjects agreed with the aid's recommendations slightly more often under the high risk condition than under the low risk condition. The situation was reversed when using the NAVPERSRANDCEN bar graph display. Subjects showed a strong tendency to maximize SEU in the low risk condition when such behavior was most appropriate. When a high risk condition occurred, the frequency of SEU maximization decreased as predicted. This effect occurred only in the bar graph condition and supports the notion that the subjects were incorporating risk into their judgments. Once again, the interaction is in line with the hypothesis that the subject is utilizing explicit information in addition to SEU and is more likely to do so under conditions of high risk. However, the difference in the amount of subject agreement with maximum SEU between the low risk case under the triangle condition and low risk under the bar graph condition (66.2% vs. 81.2%) is not explainable by the hypothesis. If information about risk is not particularly relevant, as one would expect to be the case in the low risk condition, then dependence upon the maximum SEU recommendation should be approximately the same under the DDI triangle as under the bar graph display. If dependence under one of the conditions should be greater, it ought to be the dependence under the DDI triangle because of the ease with which the maximum SEU act is interpreted. Grouping the percentages according to risk subgroups shows that the risk preferenced subgroup selected the maximum SEU act more often than the risk averse subgroup, even in the control condition. This may seem completely counter to most of the previously discussed results, which show an improvement in performance for the risk averse subgroup using the aids. Now we are saying that the very thing which the aid presented to the subject was used <u>more</u> often by the subjects who did <u>not</u> benefit from the aid. Closer investigation of the trial by trial data revealed that there were many occasions in which one alternative was so superior in terms of SEU that additional information was completely unnecessary. Occurrences of such instances could have reduced the observed effect of making information about risk more explicit.

What were the factors in addition to SEU that the subject might have been using? One obvious candidate was the variance associated with each alternative. When an alternative has the potential of resulting in a wide range of outcome (high variance), the selection of that alternative does not give the decision maker as much assurance about the consequences of his action as does the selection of an alternative with lower variance. Thus, it would be expected that the subject would be more likely to select the alternative with the minimum variance in situations of high risk.

Table 5

Percentage of Trials Subject Agreed With Maximum SEU Act

Item		DDI High	DDI Low	DDI Combined	NAVPERSRANDCEN Bar Graph High	NAVPERSRANDCEN Bar Graph Low	NAVPERSRANDCEN Bar Graph Combined	Control High	Control Low	Control Combined
I.	All Subjects	71.7	66.2	69.0	67.9	81.2	74.6	64.6	59.6	62.1
II.	Risk Averse Subgroups	57.5	65.5	63.2	60.0	76.7	67.1	60.0	55.6	57.5
III.	Risk Preferenced Subgroup	73.1	70.0	72.6	83.7	85.8	85.0	69.2	67.5	68.5

To examine this, an analysis was performed to determine the percentage of trials that the act with the minimum variance was the act that the subject selected. The results are given in Table 6. Once again, the overall means showed no difference in the aiding conditions. The mean percentage for the DDI low risk condition was much lower than the percentage for any of the other conditions. A closer inspection of the data showed that the percentages may be inflated because of the occurrence of so many instances in which the maximum SEU act and the minimum variance act were the same act. This coincidence, however, did not occur as often in the DDI low risk condition. A second analysis was performed to avoid the confounding. The figures in parentheses are the percent of trials in which the maximum SEU act was different from the minimum variance act and the subject selected the act with minimum variance. The results indicate no overall difference among the aiding conditions. However, the parenthesized figures show an apparent interaction between the aiding conditions and the risk manipulation. Although the subjects predominately select the acts which have the maximum SEU, this predominance was less under high risk when the subjects were using the DDI triangle, about the same under high and low risk when using the NAVPERSRANDCEN bar graph, and greater under high risk when using no aid at all. This result was not expected since variance information was not explicitly available in the DDI triangle.

Table 6

Percentage of Trials Subject Agreed With Minimum Variance Act

(Percentage of Trials Subject Preferred Minimum Variance Over Maximum SEU)

Item		DDI			NAVPERSRANDCEN Bar Graph			Control		
		High	Low	Combined	High	Low	Combined	High	Low	Combined
I.	All Subjects	56.5 (24.5)	14.2 (4.2)	35.2 (11.7)	30.8 (10.7)	43.7 (10.9)	37.3 (10.8)	32.1 (3.1)	32.5 (23.7)	32.3 (14.7)
II.	Risk Averse Subgroup	55.0 (35.9)	14.0 (2.6)	25.7 (9.4)	30.0 (17.3)	42.5 (7.3)	35.4 (13.2)	18.3 (3.6)	31.9 (24.3)	26.1 (15.6)
III.	Risk Preferenced Subgroup	60.9 (30.3)	15.0 (10.5)	53.2 (24.4)	32.5 (0)	45.0 (13.5)	40.0 (8.1)	45.8 (2.2)	33.8 (22.2)	41.0 (13.0)

The predominance of maximum SEU was further supported by an attempt to use a weighted linear combination of SEU and variance to predict the subjects' selection of acts. On each trial, the SEU and variance of each action alternative was standardized with respect to the SEU's and variances of the other acts on that trial. These two standard scores were weighted and summed to form a "desirability" or "preference" score for each alternative:

$$\text{Desirability of act } i = \alpha \times \text{STD SEU}_i - \beta \times \text{STD VARIANCE}_i$$
$$\text{where, } -1.0 \leq (\alpha, \beta) \leq 1.0.$$

The alternative with the maximum desirability score was taken to be the model's predicted act on that trial. The weights α and β for the linear combination were estimated by using a parameter searching program called STEPIT (Chandler, 1969) to maximize the number of correct predictions by the linear model. The fit was performed only for the high risk conditions. The resulting best fit weighting coefficients for SEU and variance are shown below:

DDI Triangle

$$D_i = (.74) \text{ STD SEU}_i - (.044) \text{ STD VARIANCE}_i$$

NAVPERSRANDCEN Bar Graph

$$D_i = (1.0) \text{ STD SEU}_i - (-1.0) \text{ STD VARIANCE}_i$$

Control

$$D_i = (1.0) \text{ STD SEU}_i - (-.13) \text{ STD VARIANCE}_i$$

The relative sizes of the weights indicate the relative contribution that the respective factors, SEU and variance, had in the establishment of an act's desirability and thence act selection. The weights emphasize the small role played by variance under the DDI triangle condition and under the control condition. The role of variance appeared to be much greater under the NAVPERSRANDCEN bar graph condition. In this condition, the combination of SEU and variance led to a substantially greater number of correctly predicted acts than did the maximum SEU model (179 corrects versus 163 corrects out of 240 trials).

Finally, the possibility that some type of minimax strategy might have been employed was examined. The most negative outcome possible for each alternative on each trial was determined. The utility associated with that outcome was weighted by the probability that that outcome would in fact occur. The act which had the least negative product was deemed the minimax act. When the maximum SEU act, minimum variance act, and the minimax act differed, the selection of the subject could reveal his performance for a strategy. The proportions of the time that the subjects were faced with this choice and picked the minimax act were computed. Unfortunately, the proportions found were based upon, at most 15 possible occurrences. Because of the design of the experiment and these few observations, little was concluded about the implications of the proportions.

The Usefulness of "Canned" Likelihood Ratios

The DDI decision aid uses a so-called "canned" or predetermined likelihood approach in which the decision makers estimate the diagnostic impact of potential data events well in advance of the actual observation of these events. Typically, these estimations are made in the planning stages of the operation, a period during which lists of possible data events and their implications are generated. The advantage of the canned likelihood ratio approach is obviously the quick response time its use makes possible. A system using canned likelihood ratios can operate in a semiautomatic mode with respect to the data. When the occurrence of a particular data event is observed, its occurrence is indicated to the system. The canned likelihood ratios associated with that event are immediately and automatically employed to update the inference algorithm, Bayes' Theorem. Thus, the updating of the posterior probabilities occurs rapidly with relatively little human intervention.

However, the predetermination of likelihood ratios does present certain problems. In this section of the paper, we will discuss two of these problems in some detail and present results from the study which have bearing upon these problems. The first of these problems to be discussed is the intersubject reliability or consistency of the subjects' estimates of the likelihood ratios. In this study, any inconsistencies in likelihood ratio estimates led to different posterior probabilities and, possibly, different decisions. The subject always began each scenario with the set of likelihood ratios which he himself estimated. Formal Bayesian updating using these likelihoods rather than some prescribed set is likely to be more descriptive of the DM's own cognitive revision and make him feel "comfortable" about using the aid. However, if the goal of decision aiding is not to emulate the DM's decision process but to optimize his decisions, it becomes imperative to conduct the Bayesian revision utilizing a likelihood set which is as close as possible to the true one. Of course, if the DM's own likelihood set is very discrepant from this true--or nearly true--set, he may feel uncomfortable using an aid which makes counter-intuitive suggestions.

The adequacy of using a particular DM's likelihood set could be assessed if it could be compared to the true likelihood set. Unfortunately, the true set is rarely obtainable. Thus, expert subjective estimates, as were used in this study, must be relied upon. When the intersubject consistency of such estimates is high, each DM's set is likely to be a good approximation of the true set. In this case, it is probably suitable to let each DM use his own likelihood set during Bayesian revisions. However, when this intersubject consistency is low, it may be necessary to obtain a prescribed likelihood set by a group estimation procedure.

The second problem is that of conditional dependence. The adequacy of the canned likelihood approach is in question. If the data are conditionally dependent, the canned likelihood ratios estimated in advance may not be appropriate for the data at the time they are actually received.

Reliability of Consistency of Subjective Estimates

Before statements about the reliability of the precanned likelihood estimates can be made, it is necessary to develop a measure which will allow the reliability or the consistency of the various likelihood estimators to be measured. The development of such a measure follows. The likelihood estimates required for both the DDI and NAVPERSRANDCEN aid consist of a vector of three conditional probabilities or likelihoods. Each likelihood is divided by the sum of the three likelihoods. The effect of this preliminary calculation is simply to normalize the likelihood vector so that the sum of its three elements is equal to one. This normalized vector can then be thought of as defining a point in a three-dimensional probability space. Technically, these normalized likelihoods are posterior probabilities computed using a uniform prior distribution. If the likelihoods for each subject are plotted in three-space in this normalized fashion, the density of the swarm of points so formed characterizes the consistency of the various likelihood estimates. Because these likelihoods are normalized, it is also the case that these points all fall on a plane defined by the sides of the DDI triangle. A plot of these points on the plane forms a scatter diagram and is then a pictorial representation of the variability in the likelihood estimates, described in terms of the triangular representation used by DDI. A descriptive measure characterizing each subject's variability can be developed by finding the centroid of this swarm of points in the DDI triangle and expressing each subject's departure from that centroid in terms of absolute distance. The centroid defines the so-called "average subject" or group consensus, and the departures from the centroid define the variability around this mean. It was assumed that the centroids best represented the group consensus and that the group consensus was the best estimate of the true likelihood ratios. Subject agreement with the group centroids was measured as the mean Euclidean distance between the subject's likelihood ratios and the group centroids. There was a considerable difference in this measure between the subject whose average distance was closest to the group centroids and the subject who was farthest from the group centroids. The mean distance for all subjects from the group centroids was a probability distance of .139. This distance is interpretable in terms of the surface contained within the DDI triangle. It means that, in a triangular space with sides equal to $\sqrt{2}$, the average subject may be conceptualized as being .14 units from the group mean. The subject whose estimates were closest in average distance to the group centroids had a mean absolute deviation from the centroids of .089, while the subject who showed the most disparity from the group centroids had a mean absolute deviation of .272. Thus, there is approximately a three-to-one difference between the subject whose estimates were most closely captured by the group centroids and the subject whose estimates were least well captured. This large difference is somewhat disturbing since it was anticipated that the estimates from a group of experts would be very closely clustered about the group centroids. The size of the difference suggests considerable subject variability, a variability which is undersirable and perhaps reducible by some type of group likelihood estimation procedure.

Another interesting aspect of consistency results from examination of likelihood estimation for the various groups of data classes. In this analysis, rather than seeking to determine how far a given subject is from the group average, we investigate how much variability exists between various estimates for each data class used in the experiment. The results of this analysis showed considerable differences between data classes in terms of how consistently the subjects assessed likelihood ratios for each class of data. Examples of data classes where there was relatively low consistency among the subjects' likelihood estimates are those for SS-N-3 surface platform activity, the SS-N-2/SNSS-N-11 platform activity, SAM platform activity, and the AS-1/2/3 platform activity. The average deviations of the estimates from the centroids for these data classes were .179, .174, .191, and .191, respectively. In contrast to the relatively high disagreement for these data classes, there were other data classes in which the subjects showed fairly close agreement. Data classes dealing with aircraft activities had a mean distance from the centroid of .069 and .087. For indicators having to do with missile launching, the mean distance from the centroid was .056 and .072, respectively. Average distance from centroids of estimates for enemy surveillance activity was .069. Clearly, some data classes create more consistent estimates than do others, and the degree of this consistency seems to be associated with the type of data class. Data classes involving surface or subsurface weapons platforms seem to be judged less consistently than data classes involving either aircraft, missiles, or surveillance.

In summary, the consistency of the subjects' canned likelihood estimates is less than ideal, and it might be advisable to investigate the feasibility of increasing the reliability by some group estimation procedures.

<u>Canned Likelihoods and Conditional Dependencies Among Data</u>

Another major obstacle to the canned likelihood approach is the existence of conditional dependencies among data. Conditional dependencies are said to occur when the interpretation that one puts upon any given datum is influenced by the occurrence or nonoccurrence of previous data. For example, if a particular datum becomes especially significant when coupled with other data previously received, then the data in question are said to be conditionally dependent. Decision-aiding systems which employ Bayes' Theorem should exploit any conditional dependencies that are present in the data. Various approaches to conditional dependence problems have been employed. These approaches for conditional dependence are discussed extensively by Steiger and Gettys (1973). The Semi-PIP approach employed by Gustafson (1969) is not a viable alternative for the DDI approach as it precludes canning of likelihoods. This approach is impractical if the patterns of conditional dependencies are extensive. The number of likelihood estimates required for each data, conditioned upon the previous data that have been seen, rapidly becomes astronomical in number. For this reason, to attempt to anticipate all of the conditional dependencies is not a viable alternative.

Another procedure, termed conditional-PIP, can be readily incorporated into the framework of the DDI concept, although there is some question of human ability to estimate conditional likelihood ratios (Steiger & Gettys, 1973). Using a conditional-PIP approach, conditional dependencies are

incorporated into the likelihood ratios by adjusting the likelihoods to reflect the impact of previous data. This adjustment necessarily involves human intervention to generate revised likelihoods that incorporate the patterns of conditional dependencies in the data. If the subject receives a datum which he believes is conditionally dependent with respect to data previously received, all he need do is adjust the likelihoods to take this conditional dependency into account. The NAVPERSRANDCEN software allowed this opportunity. If the subject believed that the canned likelihoods were inappropriate, he could modify the likelihoods at will. The new likelihoods, which incorporated the impact or moderating effect of previous data, were then utilized by the Bayesian system in lieu of the canned estimates. The percentage of temporary changes for all subjects and all scenarios was 18.53 percent. Permanent changes occurred with a frequency of 2.28 percent. The greater number of temporary changes suggests a rather frequent perception of conditional dependencies.

For these reasons, it is of considerable interest to assess in more detail the extent to which subjects were exploiting conditional dependencies in their data. Another suggestive preliminary result was obtained by plotting for each page of a scenario, as a function of the total number of data received up to and including that page, the cumulative percentage of times decision makers intervened and made temporary changes to canned likelihood values. The rationale for this analysis is the argument that data which occur late in a scenario are more likely to be conditionally dependent upon previous data than those that occur early in the scenario. If subjects were exploiting conditional dependencies, then they should have made temporary changes in the likelihoods to reflect these conditional dependencies. Therefore, if the rate at which they made these changes increased as a scenario progressed, this would be suggestive, but not conclusive, evidence for conditional dependencies in the data. Consequently, we calculated the cumulative percentage of temporary changes in likelihoods for each page of each scenario. An increase in the percentage of times the subjects made temporary changes as a scenario progressed occurred in four scenarios. The remaining scenarios showed no such clearcut trends. These preliminary results convinced us that still further analysis was justified.

A third analysis involved identifying data that, in the opinion of the scenario writer, were conditionally dependent with respect to other data. If the likelihood ratios for these data were changed in a scenario, this fact was noted. On the 24 occasions when these data were not preceded by the conditioning data, the subjects made a change in the likelihoods 8.33 percent of the time. On the 70 occasions when the data were preceded by conditioning data, changes were made 32 percent of the time. This difference in the frequency of likelihood changes is statistically reliable ($\chi^2 = 5.11$, $p < .05$). Both of these analyses are suggestive of conditional dependencies in the data which were exploited by the subjects.

Although the above analyses are suggestive of conditional dependencies among the data, there were actually two ways that a subject in our experiment could take conditional dependencies into account. The first technique was

by likelihood changes. The second technique was by changing the threat classification. If, as a result of previous data, the decision maker perceives the threat of the current datum differently and changes his classification, then this also is evidence for conditional dependence. Either a change in the likelihoods or change in threat classification, therefore, can result from conditional dependencies that the subject detects in the data. An analysis which taps the joint effect of these two techniques for incorporating conditional dependencies in the data can be performed by examining the distribution of the subjects' likelihoods for the same datum in various scenarios. Several commonly used data items which occur in a number of scenarios were identified and the subjects' likelihood responses to these data were obtained. These likelihoods were subjected to a multivariate analysis of variance. This analysis showed that, in fact, the centroids of the same data differed in a scenario-dependent manner. This result is reliable ($F = 1.6132$, $p < .0658$) and strongly suggests that, in fact, subjects were exploiting conditional dependencies present in the data either by making a likelihood change or by picking different threat classifications.

In summary, it does appear feasible to can likelihood estimates in advance if the subjects are given a means for modifying these likelihoods to exploit conditional dependencies and for incorporating unanticipated data into the scenarios. A near-instantaneous response was achieved for approximately 80 percent of the data, the remaining 20 percent required a relatively rapid likelihood estimate for further processing.

Problems With the Inference Model

It became apparent when running the system with real scenarios that there was a difficulty with the inference model. The system was sometimes slow to respond to data that were obviously diagnostic. An example of this phenomenon is presented below. It was termed the "trapped bug" phenomenon by the researchers.

The Case of the Trapped Bug

A very clear example of the trapped bug problem can be seen in the difficulties encountered by subject 6 while proceeding through one of the scenarios. After classification of datum #15 in this scenario, the system estimate of Red intent had been driven to

P (Routine) = .001 . . .

P (Harass) = .998 . . .

P (Attack) = .000 . . . , and the subject's analysis of Red intent was to classify it as harassment. In fact, all subjects judged Red's likely intent to be harassment after seeing the 15th datum of this particular scenario.

An unclassified version of the remaining five (16-20) data items in the scenario is shown in Table 7. These items occurred over a 3 minute period. A summary of the subject's analysis and system performance during this period appears in Table 8.

Table 7

Data Items Associated With a Trapped Bug

Item	Description
16	Jamming of air search radars begins.
17	Chaff usage and additional jamming occurs.
18	Target platform radar signal detected.
19	Another targeting platform radar signal detected.
20	Air-to-surface missile targeting radar detected.

Table 8

Subject Analysis and System Performance Associated With a Trapped Bug

Datum	Int	Dec	L(R)	L(H)	L(A)	P(R)	P(H)	P(A)
16	A	A	1	5	50	.00210	.999698	.000092
17	A	A	1	5	50	.000043	.999865	.000920
18	A	A	1	5	50	.000008	.990892	.009100
19	A	A	1	1	96	.000005	.531043	.468952
20	A	A	1	5	50	.0000002	.101721	.898279

Legend:
Int = subject's analysis of Red intent
Dec = subject's decision on own force action
R = routine
H = harass
A = attack
L(.) = likelihood assigned Red intent
P(.) = system probability estimate of Red intent

It can be seen that, even though the subject obviously felt he was very likely in an attack situation from datum 16 on and input likelihoods were consistent with this feeling, system probability estimates were very slow to move towards an attack indication. In other words, system indication of the existing tactical situation was not congruent with the strongly based perception of that situation by the subject.

Overall, in roughly 40 percent of the cases that an attack scenario was run in the experiment, the bug trapping problem appeared.

This lack of responsiveness apparently occurs because the inference model used by DDI is not appropriate for the TFC situation. This model assumes the inference process is "stationary," that is, the data generating process remains constant throughout the scenario. In fact, the scenarios which we used are nonstationary and the data generating process sometimes changed throughout the course of the scenario. In other words, the enemy may not exhibit any overt hostile acts until well into the scenario. Because these hostile acts do not occur until relatively late in the scenario, the system concludes that the probability of attack is vanishingly small because all data prior to the receipt of these hostile acts suggested harassment. At some time during the scenario, the Red forces change the data generating process from a "routine" or "harass" posture to an "attack" posture. This is why a system which assumes a constant data generating process does not respond to the hostile acts as rapidly as it should. We believe that a more appropriate model might be a state-change model. The world is assumed to be in a particular state and the data are related to the question: "Has the world changed from its initial state to some succeeding state?" The initial state would probably be routine operations in most situations. Each datum would be related to the question: "Has the world changed from routine to stage or routine to attack?" Data which suggested routine enemy intent would simply reassure the system that, if a change is going to take place, it has not yet occurred, but it would not be so strongly diagnostic of a future routine intent so as to trap the bug.

Unfortunately, this model would need to be more carefully explored before an assessment of its applicability can be made. We offer it only as a suggestion as a possible starting point for future work.

<u>Responses to the Questionnaire</u>

The median responses to the scaled items of the questionnaire are given, along with the questionnaire items, in Appendix B. As mentioned above, the major purpose of the questionnaire was to monitor the conduct of the investigation and to measure the effect of the intended "perceived risk" manipulation. However, there were responses to some items which are informative and germaine to the discussion of the decision aids themselves. Most notable was the strong preference of the subjects for the DDI triangle over the NAVPERSRANDCEN bar graph. The subjects felt that the bar graph contained more information but found the triangle display easier to use. By their own

admission, there evidently were some occasions in which they were confused by the bar graph display and basically ignored it. This admission was further supported by their failure to strongly disagree with statement number 7 on the questionnaire. We feel that the difference in ease of use can be reduced or even eliminated by a little additional training and experience with the more informative bar graph display. The pressing time requirement of the subjects prevented us from being more thorough in training them in the use of the aids. As a consequence, we may not have given any improvement due to explicit risk information an opportunity to manifest itself.

CONCLUSIONS

The results indicate that the ability of decision-aiding systems, such as the DDI prototype, to aid the decision maker is related to the decision maker's attitude toward risk. The performance of individuals identified as being risk averse was better when using the DDI decision aid. Risk preferenced individuals, on the other hand, did not profit from the use of either of the aids.

Although the presence of information in addition to SEU appeared to be of some use to the risk averse group, and although maximum SEU accounted for less than 75 percent of the alternatives that were selected, the exact nature of the remaining factors of choice were not determined. Both minimum variance and minimax strategies were ruled out as major factors in addition to SEU.

The results also indicate that the concept of estimating likelihood ratios for anticipated data events is viable as long as there is an opportunity for the decision maker to revise these likelihoods to reflect the conditional dependencies that are appropriate for the occurrence of particular data combinations. It appears the estimation of canned likelihood ratios might best be accomplished by some group estimation procedure.

The expert subjects participating in this research felt that computer-based decision aids, such as the ones used in this study, were realistic goals. The subjects particularly liked the DDI triangle display and had no difficulty in quickly learning to use it. The subjects were sometimes confused by the more complicated bar graph display, but also felt that it contained useful information in addition to that which they received from the DDI triangle.

This study would best be conducted if more expert subjects were available and for a longer period of time. One hesitates in strongly indicting or strongly supporting the approaches discussed here. However, no clear cut and distinct answer can ever be anticipated in simulation research such as this. The purpose of this study is served by its failure to find strong evidence for the need to incorporate certain dimensions of risk as major components of an operational decision aid. In the process of the investigation, several important issues were uncovered and several suggestions for their inclusion were determined.

RECOMMENDATIONS

Based upon the findings of this investigation, several recommendations can be made with regard to the further development and application of decision aids such as the DDI prototype.

Insofar as the dimensions typically defined to be reflective of risk are concerned, there is no strong evidence that their explicit inclusion in the decision aiding display is particularly beneficial. This is not to say that considerations of risk are unimportant, but that the study was not able to identify any particular dimension of risk that was important. Unless subsequent research indicates differently, it is recommended that there be continued development of the maximum SEU approach employed by Decisions and Designs, Inc. This recommendation is based primarily upon the subjects' selection of the maximum SEU act in almost two-thirds (62.1%) of the trails--even when no aid was present. Although the presence of explicit risk information in the NAVPERSRANDCEN version did not enhance performance significantly, the participants in the investigation felt that it provided valuable information which may be more important in other settings. Thus, further development of decision analytic aids might incorporate into the aids the ability for the user to have access to risk information upon request.

The aids were beneficial only to those subjects who became more risk averse under conditions of high risk. Thus, the use of such aids might be limited to those individuals who can benefit from the use of such aids. If so, it is necessary that a reliable technique be developed to make that identification. The results of such identification could impact upon training and/or the configuration of such aids available to the decision maker.

If a technique to be used for decision aiding requires reliable subjective estimates, as does the Bayesian approach, some consideration should be given to the use of estimation procedures which yield increased reliability. One possibility could be some type of group estimation procedure.

Additionally, the use of techniques requiring estimates, such as the likelihood ratio, should be accompanied by the ability of the user of the decision aid to update or change the estimate to reflect conditional dependencies in the data.

There is also a specific recommendation with regard to the Bayesian approach used by DDI. Because of the distinct problem of the "trapped bug," it is recommended that the decision task associated with the use of the DDI aid be expanded to include an assessment of the probability that the enemy has changed its intent. This is in addition to the basic task of diagnosing enemy intent and selecting the appropriate action.

REFERENCES

Allais, M. Le comportement de l'homme rationnel devant le risque: Critique des postulats et axioms de l'ecole Americaine. Econometrica, 1953, 21, 503-546.

Barclay, S., Brown, R. V., Chinnis, J. O., Kelly, C. W., & Peterson, C. R. Handbook for decision analysis. McLean, VA: Decisions and Designs, Inc., 1973.

Brown, R. V., Peterson, C. R., Shawcross, W. H., & Ulvila, J. W. Decision analysis as an element in an operational decision aiding system (phase II) (DDI Tech. Rep. 75-13). McLean, VA: Decisions and Designs, Inc., November 1975.

Chandler, J. P. STEPIT: Finds local minima of a smooth function of several parameters (CPA-312). Behavioral Science, 1969, 14, 81-82.

Coombs, C. H., & Pruitt, D. G. Components of risk in decision making: Probability and variance preferences. Journal of Experimental Psychology, 1960, 60, 265-277.

Gustafson, D. Evaluation of probabilistic information in medical decision making. Organizational Behavior and Human Performance, 1969, 4, 20-34.

Hollander, M., & Wolfe, D. Nonparametric statistical methods. New York: John Wiley & Sons, 1973.

Payne, J. R., & Rowney, J. V. ONRODA warfare scenario (SRI Research Memorandum NWRC-RM-83). Menlo Park, CA: Stanford Research Institute, June 1975.

Payne, J. W. Relation of perceived risk to preferences among gambles. Journal of Experimental Psychology, 1975, 104(1), 86-94.

Payne, J. W., & Braunstein, M. L. Preferences among gambles with equal underlying distributions. Journal of Experimental Psychology, 1971, 87, 13-18.

Pollatsek, A., & Tversky, A. A theory of risk. Journal of Mathematical Psychology, 1970, 7, 540-553.

Raiffa, H. Decision analysis: Introductory lectures on choices under uncertainty. Reading, MA: Addison-Wesley, 1968.

Rapoport, A., & Wallsten, T. Individual decision behavior. Annual Review of Psychology, 1972, 23, 131-176.

Slovic, P. The relative influence of probabilities and payoffs upon perceived risk of a gamble. Psychonomic Science, 1967, 9(4), 223-224.

Slovic, P. Choice between equally-valued alternatives. Journal of Experimental Psychology: Human Perception and Performance, 1975, 1(3), 280-287.

Slovic, P., & Lichtenstein, S. Importance of variance preferences in gambling decisions. Journal of Experimental Psychology, 1968, 78, 646-654.

Steiger, J. H., & Gettys, C. F. Conditional dependence and decomposition strategies in diagnostic inference systems. Organizational Behavior and Human Performance, 1973, 10, 88-107.

Tversky, A. Elimination by aspects: A theory of choice. Psychological Review, 1972, 79, 281-299.

von Neumann, J., & Morgenstern, O. Theory of games and economic behavior. Princeton, NJ: Princeton University Press, 1953.

APPENDIX A

SCENARIO EXAMPLE

SCENARIO 1

I. U. S. FORCES

A. CV WITH PLANE GUARD DESTROYER

B. DESTROYER 50 NM AHEAD OF CV (LEAD DESTROYER)

C. DESTROYER 50 NM BEHIND CV (TRAIL DESTROYER)

TASK FORCE IS HEADING 090° TOWARDS ONRODA, WHICH LIES 1000 NM AWAY. SOA IS 12 KTS.

II. RED FORCES

A. KOTLIN TATTLETALE

B. KRESTA I 100 NM NORTH

C. KYNDA 70 NM EAST

ALL BEARINGS AND DISTANCES ARE RELATIVE TO THE CV UNLESS OTHERWISE NOTED.

1-0

TIME OF PREVIOUS DATUM:
-

TIME OF CURRENT DATUM:
1200 12 APRIL

CURRENT DATUM:
S-3 WORKING SONOBUOY PATTERN 90 NM EAST OF THE CV REPORTS INDICATIONS OF A CHARLIE SUBMARINE CLOSING ON THE TASK FORCE.

DATUM CLASSIFICATION:

C. SS-N-7 PLATFORM ACTIVITY

1. THREATENING ACTION-WITHIN WEAPONS RANGE
2. THREATENING ACTION-OUTSIDE WEAPONS RANGE
3. AMBIGUOUS ACTION
4. NON-THREATENING ACTION

BOGEY TOTE

BRG	TN	CUS	SPD	ALT	COMP	TIME	REMARKS

SURFACE STATUS

SK	BRG	RNG	TIME	CUS	SPD	
A	270	2	1200	090	12	KOTLIN
B	360	100	1200	090	12	KRESTA I
C	090	70	1200	090	12	KYNDA

ASW CONTACT STATUS

DESIG	POSIT	TIME	BY WHOM/HOW	CLASS	REMARKS
A	090/90	1200	S-3/BUOY	CHARLIE	SS-N-7

EW STATUS

BRK	TN	FREQ	BRG	TIME	PLATFORM	THREAT	REMARKS

1-1

TIME OF PREVIOUS DATUM:

1200 12 APRIL

TIME OF CURRENT DATUM:

1237 12 APRIL

CURRENT DATUM:

— OBSERVED FROM KOTLIN TATTLETALE.

DATUM CLASSIFICATION:

F. SURFACE-TO-SURFACE GUN PLATFORM ACTIVITY

1. THREATENING ACTION
2. *AMBIGUOUS ACTION*
3. NON-THREATENING ACTION

BOGEY TOTE

BRG	TN	CUS	SPD	ALT	COMP	TIME	REMARKS

SURFACE STATUS

SK	BRG	RNG	TIME	CUS	SPD	
A	270	2	1237	090	12	KOTLIN
B	360	100	1237	090	12	KRESTA I
C	090	70	1237	090	12	KYNDA

ASW CONTACT STATUS

DESIG	POSIT	TIME	BY WHOM/HOW	CLASS	REMARKS
A	090/70	1237	S-3/BUOY	CHARLIE	SS-N-7

EW STATUS

RAK	TN	FREQ	BRG	TIME	PLATFORM	THREAT	REMARKS

1-2

TIME OF PREVIOUS DATUM

1237 12 APRIL

TIME OF CURRENT DATUM

1239 12 APRIL

CURRENT DATUM

-- BY KOTLIN TATTLETALE CEASES.

DATUM CLASSIFICATION

F. SURFACE-TO-SURFACE GUN PLATFORM ACTIVITY

1. THREATENING ACTION
2. AMBIGUOUS ACTION
3. NON-THREATENING ACTION

BOGEY TOTE

BRG	TN	CUS	SPD	ALT	COMP	TIME	REMARKS

SURFACE STATUS

SK	BRG	RNG	TIME	CUS	SPD	
A	270	2	1239	090	12	KOTLIN
B	360	100	1239	090	12	KRESTA I
C	090	70	1239	090	12	KYNDA

ASW CONTACT STATUS

DESIG.	POSIT	TIME	BY WHOM/HOW	CLASS	REMARKS
A	090/70	1239	S-3/BUOY	CHARLIE	SS-N-7

EW STATUS

RAK	TN	FREQ	BRG	TIME	PLATFORM	THREAT	REMARKS

TIME OF PREVIOUS DATUM:
1239 12 APRIL

TIME OF CURRENT DATUM:

1250 - 1254 12 APRIL

CURRENT DATUM:
BRIEF PERIOD OF INCREASED ENEMY SURVEILLANCE ACTIVITY OBSERVED.

DATUM CLASSIFICATION:

M. ENEMY SURVEILLANCE ACTIVITY

1. INCREASE
2. NORMAL
3. DECREASE

BOGEY TOTE

BRG	TN	CUS	SPD	ALT	COMP	TIME	REMARKS

SURFACE STATUS

SK	BRG	RNG	TIME	CUS	SPD	
A	270	2	1254	090	12	KOTLIN
B	360	100	1254	090	12	KRESTA I
C	090	70	1254	090	12	KYNDA

ASW CONTACT STATUS

DESIG	POSIT	TIME	BY WHOM/HOW	CLASS	REMARKS
A	090/60	1254	S-3/BUOY	CHARLIE	SS-N-7

EW STATUS

RAK	TN	FREQ	BRG	TIME	PLATFORM	THREAT	REMARKS

1-4

TIME OF PREVIOUS DATUM

1254 12 APRIL

TIME OF CURRENT DATUM

1530 12 APRIL

CURRENT DATUM

LEAD DESTROYER REPORTS —
FROM BEARING OF KYNDA

DATUM CLASSIFICATION

A. SS-N-3 SURFACE PLATFORM ACTIVITY

1. THREATENING ACTION-WITHIN WEAPONS RANGE
2. THREATENING ACTION-OUTSIDE WEAPONS RANGE
3. AMBIGUOUS ACTION
4. NON-THREATENING ACTION

BOGEY TOTE							
BRG	TN	CUS	SPD	ALT	COMP	TIME	REMARKS

SURFACE STATUS						
SK	BRG	RNG	TIME	CRS	SPD	
A	270	2	1530	090	12	KOTLIN
B	360	100	1530	090	12	KRESTA I
C	090	70	1530	090	12	KYNDA

ASW CONTACT STATUS					
DESIG	POSIT	TIME	BY WHOM/HOW	CLASS	REMARKS
A	090/15	1530	LEAD DESTR-OYER/SONAR	CHARLIE	SS-N-7

EW STATUS							
RAK	TN	FREQ	BRG	TIME	PLATFORM	THREAT	REMARKS

TIME OF PREVIOUS DATUM:

1530 12 APRIL

TIME OF CURRENT DATUM:

1531 12 APRIL

CURRENT DATUM:

—— FROM BEARING OF KYNDA CEASES.

DATUM CLASSIFICATION:

A. SS-N-3 SURFACE PLATFORM ACTIVITY

1. THREATENING ACTION-WITHIN WEAPONS RANGE
2. THREATENING ACTION-OUTSIDE WEAPONS RANGE
3. AMBIGUOUS ACTION
4. NON-THREATENING ACTION

BOGEY TOTE

BRG	TN	CUS	SPD	ALT	COMP	TIME	REMARKS

SURFACE STATUS

SK	BRG	RNG	TIME	CUS	SPD	
A	270	2	1531	090	12	KOTLIN
B	360	100	1531	090	12	KRESTA I
C	090	70	1531	090	12	KYNDA

ASW CONTACT STATUS

DESIG	POSIT	TIME	BY WHOM/HOW	CLASS	REMARKS
A	090/15	1531	LEAD DESTR-DYER/SONAR	CHARLIE	SS-N-7

EW STATUS

RAK	TN	FREQ	BRG	TIME	PLATFORM	THREAT	REMARKS

1-6

TIME OF PREVIOUS DATUM

1531 12 APRIL

TIME OF CURRENT DATUM

1733 12 APRIL

CURRENT DATUM

LEAD DESTROYER AGAIN REPORTS --- FROM THE BEARING OF KYNDA.

DATUM CLASSIFICATION

A. SS-N-3 SURFACE PLATFORM ACTIVITY

1. THREATENING ACTION-WITHIN WEAPONS RANGE
2. THREATENING ACTION-OUTSIDE WEAPONS RANGE
3. AMBIGUOUS ACTION
4. NON-THREATENING ACTION

BOGEY TOTE

BRG.	[illegible]	[illegible]	[illegible]	ALT	[illegible]	TIME	[illegible]

SURFACE STATUS

SK	BRG.	RNG	TIME	[illegible]	[illegible]	
A	270	2	1733	090	12	KOTLIN
B	360	100	1733	090	12	KRESTA I
C	090	70	1733	090	12	KYNDA

ASW CONTACT STATUS

DESIG	POSIT	TIME	BY WHOM/HOW	CLASS	REMARK
A	090/15	1733	LEAD DESTROYER/SONAR	CHARLIE	SS-N-7

EW STATUS

[illegible]	[illegible]	FREQ	BRG.	TIME	PLATFORM	THREAT	REMARK

TIME OF PREVIOUS DATUM:

1733 12 APRIL

TIME OF CURRENT DATUM:

1736 12 APRIL

CURRENT DATUM:

______ FROM BEARING OF KYNDA CEASES.

DATUM CLASSIFICATION:

A. SS-N-3 SURFACE PLATFORM ACTIVITY

1. THREATENING ACTION-WITHIN WEAPONS RANGE
2. THREATENING ACTION-OUTSIDE WEAPONS RANGE
3. AMBIGUOUS ACTION
4. NON-THREATENING ACTION

BOGEY TOTE

BRG	TN	CUS	SPD	ALT	COMP	TIME	REMARKS

SURFACE STATUS

SK	BRG	RNG	TIME	CUS	SPD	
A	270	2	1736	090	12	KOTLIN
B	360	100	1736	090	12	KRESTA I
C	090	70	1736	090	12	KYNDA

ASW CONTACT STATUS

DESIG	POSIT	TIME	BY WHOM/HOW	CLASS	REMARKS
A	090/15	1736	LEAD DESTR-OYER/SONAR	CHARLIE	SS-N-7

EW STATUS

RAK	TN	FREQ	BRG	TIME	PLATFORM	THREAT	REMARKS

1-8

TIME OF PREVIOUS DATUM:

1736 12 APRIL

TIME OF CURRENT DATUM:

1755 12 APRIL

CURRENT DATUM

PLANE GUARD REPORTS SONAR CONTACT ON PROBABLE CHARLIE SUBMARINE 15 NM NORTH OF THE CV.

DATUM CLASSIFICATION

C. <u>SS-N-7 PLATFORM ACTIVITY</u>

1. THREATENING ACTION-WITHIN WEAPONS RANGE
2. THREATENING ACTION-OUTSIDE WEAPONS RANGE
3. AMBIGUOUS ACTION
4. NON-THREATENING ACTION

BOGY TOTE

BRG	TN	CUS	SPD	ALT	COMP	TIME	REMARKS

SURFACE STATUS

SK	BRG	RNG	TIME	CUS	SPD	
A	270	2	1755	090	12	KOTLIN
B	360	100	1755	090	12	KRESTA I
C	090	70	1755	090	12	KYNDA

ASW CONTACT STATUS

DESIG	POSIT	TIME	BY WHOM/HOW	CLASS	REMARKS
A	090/15	1755	LEAD DESTR-OYER/SONAR	CHARLIE	SS-N-7
B	360/15	1755	PLANE GUARD/SONAR	CHARLIE	SS-N-7

EW STATUS

RAK	TN	FREQ	BRG	TIME	PLATFORM	THREAT	REMARKS

1-9

TIME OF PREVIOUS DATUM:

1755 12 APRIL

TIME OF CURRENT DATUM:

1830-1834 12 APRIL

CURRENT DATUM:

TASK FORCE AGAIN DETECTS A BRIEF PERIOD OF ENEMY SURVEILLANCE ACTIVITY INCREASE

DATUM CLASSIFICATION:

M. ENEMY SURVEILLANCE ACTIVITY

1. INCREASE
2. NORMAL
3. DECREASE

BOGEY TOTE

BRG	TN	CUS	SPD	ALT	COMP	TIME	REMARKS

SURFACE STATUS

SK	BRG	RNG	TIME	CUS	SPD	
A	270	2	1834	090	12	KOTLIN
B	360	100	1834	090	12	KRESTA I
C	090	70	1834	090	12	KYNDA

ASW CONTACT STATUS

DESIG	POSIT	TIME	BY WHOM/HOW	[illegible]	REMARKS
A	090/15	1834	LEAD DESTR-OYER/SONAR	CHARLIE	SS-N-7
B	360/15	1834	PLANE GUARD/SONAR	CHARLIE	SS-N-7

EW STATUS

RAK	TN	FREQ	BRG	TIME	PLATFORM	THREAT	REMARKS

1-10

TIME OF PREVIOUS DATUM:

1834 12 APRIL

TIME OF CURRENT DATUM:

2145 12 APRIL

CURRENT DATUM:

P-3 WORKING 120 NM WEST REPORTS TRACKING AN ECHO II SUBMARINE.

DATUM CLASSIFICATION:

B. SS-N-3 SUBMARINE PLATFORM ACTIVITY

1. THREATENING ACTION-WITHIN WEAPONS RANGE
2. THREATENING ACTION-OUTSIDE WEAPONS RANGE
3. AMBIGUOUS ACTION
4. NON-THREATENING ACTION

BOGEY TOTE

BRG.	TN	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

SURFACE STATUS

SK	BRG	RNG	TIME	[illegible]	[illegible]	
A	270	2	2145	090	12	KOTLIN
B	360	100	2145	090	12	KRESTA I
C	090	70	2145	090	12	KYNDA

ASW CONTACT STATUS

DESIG	POSIT	TIME	BY WHOM/HOW	CLASS	REMARKS
A	090/15	2145	LEAD DESTR-OYER/SONAR	CHARLIE	SS-N-7
B	360/15	2145	PLANE GUARD/SONAR	CHARLIE	SS-N-7
C	270/120	2145	P-3/BUOY	ECHO II	SS-N-3

EW STATUS

RAK	TN	FREQ	BRG	TIME	PLATFORM	THREAT	REMARKS

I-11

TIME OF PREVIOUS DATUM:
2145 12 APRIL

TIME OF CURRENT DATUM:

0100 13 APRIL

CURRENT DATUM:
RADAR CONTACT ON TARGET INBOUND FROM 030°/— NM AT 30000', SPEED 250 KTS. TENTATIVELY CLASSIFIED AS A BEAR D.

DATUM CLASSIFICATION:

G. <u>TARGETING PLATFORM (BEAR D/HORMONE) ACTIVITY</u>

1. THREATENING ACTION-NO BIG BULGE OR VDL
2. THREATENING ACTION-BIG BULGE BUT NO VDL
3. THREATENING ACTION-VDL
4. AMBIGUOUS ACTION
5. NON-THREATENING ACTION

BOGEY TOTE

BRG	TN	CUS	SPD	ALT	COMP	TIME	REMARKS
030	1	210	—	300	ONE	0100	BEAR D

SURFACE STATUS

SK	BRG	RNG	TIME	CUS	SPD	
A	270	2	0100	090	12	KOTLIN
B	360	100	0100	090	12	KRESTA I
C	090	70	0100	090	12	KYNDA

ASW CONTACT STATUS

DESIG	POSIT	TIME	BY WHOM/HOW	CLASS	REMARKS
A	090/15	0100	LEAD DESTR-OYER/SONAR	CHARLIE	SS-N-7
B	360/15	0100	PLANE GUARD/SONAR	CHARLIE	SS-N-7
C	270/120	0100	P-3/BUOY	ECHO II	SS-N-3

EW STATUS

RAK	TN	FREQ	BRG	TIME	PLATFORM	THREAT	REMARKS

I-12

TIME OF PREVIOUS DATUM:

0100 13 APRIL

TIME OF CURRENT DATUM:

0112 13 APRIL

CURRENT DATUM:

— OBSERVED FROM THE INBOUND BEAR.

DATUM CLASSIFICATION:

G. TARGETING PLATFORM (BEAR D/HORMONE) ACTIVITY

1. THREATENING ACTION-NO BIG BULGE OR VDL
2. THREATENING ACTION-BIG BULGE BUT NO VDL
3. *THREATENING ACTION-VDL*
4. AMBIGUOUS ACTION
5. NON-THREATENING ACTION

BOGEY TOTE

BRG	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
030	1	210	–	300	ONE	0112	BEAR D

SURFACE STATUS

SK	BRG	RNG	[illegible]	[illegible]	[illegible]	
A	270	2	0112	090	12	KOTLIN
B	360	100	0112	090	12	KRESTA I
C	090	70	0112	090	12	KYNDA

ASW CONTACT STATUS

[illegible]	[illegible]	TIME	[illegible]	[illegible]	[illegible]
A	090/15	0112	LEAD DESTR-OYER/SONAR	CHARLIE	SS-N-7
B	360/15	0112	PLANE GUARD/SONAR	CHARLIE	SS-N-7
C	270/120	0112	P-3/BUOY	ECHO II	SS-N-3

EW STATUS

[illegible]	[illegible]	[illegible]	[illegible]	TIME	[illegible]	[illegible]	[illegible]

1-13

TIME OF PREVIOUS DATUM:
0112 13 APRIL

TIME OF CURRENT DATUM:
0137 13 APRIL

CURRENT DATUM:
BEAR AIRCRAFT BEGINS ORBITING AT — NM.

DATUM CLASSIFICATION:

G. TARGETING PLATFORM (BEAR D/HORMONE) ACTIVITY

1. THREATENING ACTION-NO BIG BULGE OR VDL
2. THREATENING ACTION-BIG BULGE BUT NO VDL
3. THREATENING ACTION-VDL
4. AMBIGUOUS ACTION
5. NON-THREATENING ACTION

BOGEY TOTE

BRG	TN	[illegible]	SPD	ALT	[illegible]	[illegible]	REMARKS
030	1	ORBIT		300	ONE	0137	BEAR D

SURFACE STATUS

SK	BRG	RNG	TIME			
A	270	2	0137	090	12	KOTLIN
B	360	100	0137	090	12	KRESTA I
C	090	70	0137	090	12	KYNDA

ASW CONTACT STATUS

DESIG	POSIT	TIME	BY WHOM/HOW	[illegible]	[illegible]
A	090/15	0137	LEAD DESTR-OYER/SONAR	CHARLIE	SS-N-7
B	360/15	0137	PLANE GUARD/SONAR	CHARLIE	SS-N-7
C	270/120	0137	P-3/BUOY	ECHO II	SS-N-3

EW STATUS

RAK	TN	FREQ	BRG	TIME	PLATFORM	THREAT	REMARKS

1-14

TIME OF PREVIOUS DATUM

0137 13 APRIL

TIME OF CURRENT DATUM

0150 13 APRIL

CURRENT DATUM

— OBSERVED FROM THE ORBITING BEAR.

DATUM CLASSIFICATION

G. TARGLTING PLATFORM (BEAR D/HORMONE) ACTIVITY

1. THREATENING ACTION-NO BIG BULGF OR VDL
2. THREATENING ACTION-BIG BULGE BUT NO VDL
3. THREATENING ACTION-VDI
4. AMBIGUOUS ACTION
5. NON-THREATENING ACTION

BOGEY TOTE

BRG	IN	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
030	1	ORBIT		300	ONE	0150	BEAR D

SURFACE STATUS

[illegible]	BRG	RNG	TIME	[illegible]	[illegible]	
A	270	2	0150	090	12	KOTLIN
B	360	100	0150	090	12	KRESTA I
C	090	70	0150	090	12	KYNDA

ASW CONTACT STATUS

[illegible]	[illegible]	TIME	[illegible]	[illegible]	[illegible]
A	090/15	0150	LEAD DESTR-OYER/SONAR	CHARLIE	SS-N-7
B	360/15	0150	PLANE GUARD/SONAR	CHARLIE	SS-N-7
C	270/120	0150	P-3/BUOY	ECHO II	SS-N-3

EW STATUS

[illegible]	IN	FREQ	[illegible]	TIME	PLATFORM	[illegible]	[illegible]

TIME OF PREVIOUS DATUM:
0150 13 APRIL

TIME OF CURRENT DATUM:
0152 13 APRIL

CURRENT DATUM:
P-3 REPORTS A SURFACE CONTACT IN THE AREA WHERE IT HAS BEEN TRACKING THE ECHO II SUBMARINE.

DATUM CLASSIFICATION
B. <u>SS-N-3 SUBMARINE PLATFORM ACTIVITY</u>

1. THREATENING ACTION-WITHIN WEAPONS RANGE
2. THREATENING ACTION-OUTSIDE WEAPONS RANGE
3. AMBIGUOUS ACTION
4. NON-THREATENING ACTION

BOGEY TOTE

BRG	TN	CUS	SPD	ALT	COMP	TIME	[illegible]
030	1	ORBIT		300	ONE	0152	BEAR D

SURFACE STATUS

SK	BRG	RNG	TIME	CUS	[illegible]	
A	270	2	0152	090	12	KOTLIN
B	360	100	0152	090	12	KRESTA I
C	090	70	0152	090	12	KYNDA
D	270	120	0152		12	ECHO II

ASW CONTACT STATUS

DESIG	POSIT	TIME	BY WHOM/HOW	[illegible]	[illegible]
A	090/15	0152	LEAD DESTROYER/SONAR	CHARLIE	SS-N-7
B	360/15	0152	PLANE GUARD/SONAR	CHARLIE	SS-N-7
C	270/120	0150	P-3/BUOY	ECHO II	SS-N-3

EW STATUS

RAK	TN	FREQ	BRG	TIME	PLATFORM	THREAT	REMARKS

1-16

TIME OF PREVIOUS DATUM

0152 13 APRIL

TIME OF CURRENT DATUM

0153 13 APRIL

CURRENT DATUM

LEAD DESTROYER REPORTS ____ FROM BEARING OF KYNDA FOLLOWED IMMEDIATELY BY ______. THEN _____ CEASES.

DATUM CLASSIFICATION

____

BOGEY TOTE							
[illegible]	IN	[illegible]	[illegible]	ALT	[illegible]	[illegible]	[illegible]
030	1	ORBIT		300	ONE	0153	BEAR D

SURFACE STATUS						
[illegible]	[illegible]	[illegible]	TIME	[illegible]	[illegible]	
A	270	2	0153	090	12	KOTLIN
B	360	100	0153	090	12	KRESTA I
C	090	70	0153	090	12	KYNDA
D	270	120	0153		12	ECHO II

ASW CONTACT STATUS					
DESIG.	[illegible]	TIME	[illegible]	[illegible]	[illegible]
A	090/15	0153	LEAD DESTR-OYER/SONAR	CHARLIE	SS-N-7
B	360/15	0153	PLANE GUARD/SONAR	CHARLIE	SS-N-7
C	270/120	0150	P-3/BUOY	ECHO II	SS-N-3

EW STATUS							
[illegible]	IN	[illegible]	[illegible]	TIME	[illegible]	[illegible]	[illegible]

TIME OF PREVIOUS DATUM:

0153 13 APRIL

TIME OF CURRENT DATUM:

0154 13 APRIL

CURRENT DATUM:

PLANE GUARD REPORTS
FROM BEARING OF KOTLIN

DATUM CLASSIFICATION:

F. SURFACE-TO-SURFACE
GUN PLATFORM ACTIVITY

1. THREATENING ACTION
2. AMBIGUOUS ACTION
3. NON-THREATENING ACTION

BOGEY TOTE

BRG	TN	CUS	SPD	ALT	[illegible]	[illegible]	REMARKS
030	1		ORBIT	300	ONE	0154	BEAR D

SURFACE STATUS

SK	BRG	RNG	TIME	CUS	[illegible]	
A	270	2	0154	090	12	KOTLIN
B	360	100	0154	090	12	KRESTA I
C	090	70	0154	090	12	KYNDA
D	270	120	0154		12	ECHO II

ASW CONTACT STATUS

DESIG	POSIT	TIME	BY WHOM/HOW	CLASS	REMARKS
A	090/15	0154	LEAD DESTR-OYER/SONAR	CHARLIE	SS-N-7
B	360/15	0154	PLANE GUARD/SONAR	CHARLIE	SS-N-7
C	270/120	0150	P-3/BUOY	ECHO II	SS-N-3

EW STATUS

RAK	TN	FREQ	BRG	TIME	PLATFORM	THREAT	REMARKS

1-18

TIME OF PREVIOUS DATUM

0154 13 APRIL

TIME OF CURRENT DATUM

0154 13 APRIL

CURRENT DATUM

_____ FROM BEAR CEASES.

DATUM CLASSIFICATION

G. TARGETING PLATFORM (BEAR D/HORMONE) ACTIVITY

1. THREATENING ACTION-NO BIG BULGE OR VDL
2. THREATENING ACTION-BIG BULGE BUT NO VDL
3. THREATENING ACTION-VDL
4. AMBIGUOUS ACTION
5. NON-THREATENING ACTION

BOGEY TOTE

BRG	TN	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
030	1		ORBIT	300	ONE	0154	BEAR D

SURFACE STATUS

[illegible]	BRG	RNG	TIME	[illegible]	[illegible]	
A	270	2	0154	090	12	KOTLIN
B	360	100	0154	090	12	KRESTA I
C	090	70	0154	090	12	KYNDA
D	270	120	0154		12	ECHO II

ASW CONTACT STATUS

[illegible]	[illegible]	[illegible]	[illegible]
A	090/15	0154	LEAD DESTROYER/SONAR CHARLIE [illegible]
B	360/15	0154	PLANE GUARD/SONAR CHARLIE SS-N-7
C	270/120	0150	P-3/BUOY ECHO II SS-N-3

EW STATUS

RAR	TN	FREQ	BRG	TIME	PLATFORM	THREAT	[illegible]

TIME OF PREVIOUS DATUM:

0154 13 APRIL

TIME OF CURRENT DATUM:

0154 13 APRIL

CURRENT DATUM:

HIGH SPEED (1.3 MACH) TARGET DETECTED INBOUND TO THE CV FROM 360°/10NM AT 700'. CLASSIFIED AS A VAMPIRE.

DATUM CLASSIFICATION:

K. <u>LAUNCHED MISSILE (SS) INDICATION</u>

1. STRONG INDICATOR
2. WEAK INDICATOR

BOGEY TOTE

BRG	TN	CUS	SPD	ALT	COMP	TIME	REMARKS
030	1	ORBIT		300	ONE	0154	BEAR D
360	V1	180	1.3	7	ONE	0154	VAMPIRE

SURFACE STATUS

SK	BRG	RNG	TIME	CUS	SPD	
A	270	2	0154	090	12	KOTLIN
B	360	100	0154	090	12	KRESTA I
C	090	70	0154	090	12	KYNDA
D	270	120	0154		12	ECHO II

ASW CONTACT STATUS

DESIG	POSIT	TIME	BY WHOM/HOW	CLASS	REMARKS
A	090/15	0154	LEAD DESTROYER/SONAR	CHARLIE	SS-N-7
B	360/15	0154	PLANE GUARD/SONAR	CHARLIE	SS-N-7
C	270/120	0150	P-3/BUOY	ECHO II	SS-N-3

EW STATUS

RAK	TN	FREQ	BRG	TIME	PLATFORM	[illegible]	[illegible]

1-20

APPENDIX B

DEBRIEFING QUESTIONNAIRE

DEBRIEFING QUESTIONNAIRE

I. Please use the following scale to indicate how much you agree with each of the following statements.

Strongly Disagree				Strongly Agree
1	2	3	4	5

MdN Response		
4.5	1.	The use of computer based systems for decision aiding in tactical operations is a realistic goal for the near future.
4.75	2.	Considering the limited time available, the briefing and instructions were sufficient for using the decision aids.
4.16	3.	The problems used in the study were realistic and plausible.
2.00	4.	When there were 3 CVA's available instead of 1 CVA, it was more important to select the correct action.
3.83	5.	It was relatively easy to classify each data event as belonging to one of the categories given at the bottom of each page.
2.00	6.	There were many occasions in which the appropriate classification was not one of the alternatives available.
2.10	7.	I didn't pay much attention to the information presented in the display.
2.30	8.	I sometimes disagreed with the display at first, but noticed information that convinced me that I was wrong.
1.83	9.	None of the displays seem to be particularly helpful in analyzing the tactical situations.
4.25	10.	The triangle display was more useful than the bar graph display.
2.00	11.	The bar graph display was more useful than the triangle display.
4.50	12.	The triangle display was the easiest to use.
3.30	13.	The bar graph contained more information than the triangle display.
3.70	14.	The concept of "likelihood" was easy to comprehend.

II. The following questions will only be used for evaluating the utility of the various aids relative to your experience.

A. Military rank? ______________________

B. Number of years in the Navy? ______________

C. What were some of the difficulties you had with the displays?

____

____

____

____

____

D. What pieces of information would enhance the use of the aid for decision making?

____

____

____

E. Which aid was the most useful, and why did you prefer it?

____

____

____

III. If a "follow-up" study is conducted in the near future, would you be willing to participate for a couple of hours at your convenience? ________

APPENDIX C

LIKELIHOOD ESTIMATE FORM

PARTICIPANT # ______

ASSESSMENT OF RED INTENT INDICATORS

INDICATOR	RED INTENT ROUTINE	HARASS	ATTACK
A. SS-N-3 Surface Platform Activity:			
1. Threatening action-within weapons range			
2. Threatening action-outside weapons range			
3. Ambiguous action			
4. Non-threatening action			
B. SS-N-3 Submarine Platform Activity:			
1. Threatening action-within weapons range			
2. Threatening action-outside weapons range			
3. Ambiguous action			
4. Non-threatening action			
C. SS-N-7 Platform Activity:			
1. Threatening action-within weapons range			
2. Threatening action-outside weapons range			
3. Ambiguous action			
4. Non-threatening action			
D. SS-N-2/SS-N-11 Platform Activity:			
1. Threatening action-within weapons range			
2. Threatening action-outside weapons range			
3. Ambiguous action			
4. Non-threatening action			

PARTICIPANT # ______

ASSESSMENT OF RED INTENT INDICATORS

INDICATOR	RED INTENT		
	ROUTINE	HARASS	ATTACK
E. SAM Platform Activity:			
1. Threatening action			
2. Ambiguous action			
3. Non-threatenting			
F. Surface-to-Surface Gun Platform Activity:			
1. Threatening action			
2. Ambiguous action			
3. Non-threatening action			
G. Targeting Platform (Bear D/Hormone) Activity:			
1. Threatening action-no Big Bulge or VDL			
2. Threatening action-Big Bulge but no VDL			
3. Threatening action-VDL			
4. Ambiguous action			
5. Non-threatening action			
H. AS-1/2/3 Etc Platform Activity:			
1. Threatening action-within weapons range			
2. Threatening action-outside weapons range			
3. Ambigous action			
4. Non-threatening action			

PARTICIPANT # ______

ASSESSMENT OF RED INTENT INDICATORS

INDICATOR	RED INTENT		
	ROUTINE	HARASS	ATTACK
I. Tactical Aircraft Activity:			
1. Threatening action			
2. Ambiguous action			
3. Non-threatening action			
J. Other Aircraft (e.g. Badger D/E) Activity:			
1. Threatening action			
2. Ambiguous action			
3. Non-threatening action			
K. Launched Missile (SS) Indication:			
1. Strong indicator			
2. Weak indicator			
L. Launched Missile (SA) Indication:			
1. Strong indicator			
2. Weak indicator			
M. Enemy Surveillance Activity:			
1. Increase			
2. Normal			
3. Decrease			
N. Enemy Communication Activity:			
1. Increase			
2. Normal			
3. Decrease			

PARTICIPANT # ______

ASSESSMENT OF RED INTENT INDICATORS

INDICATOR	RED INTENT		
	ROUTINE	HARASS	ATTACK
0. Enemy Diplomatic Activity:			
1. Threatening action			
2. Ambiguous action			
3. Non-threatening action			

APPENDIX D

PERFORMANCE DETERMINATION

THE DETERMINATION OF SUBJECT PERFORMANCE SCORES

The scenario author had designed some scenarios as ultimately displaying an overall Red intent of conducting either routine operations or harassment. For those scenarios, the subject received, as a score at each page of the scenario, that value from his appropriate utility table corresponding to the action he selected at that page and the Red intent which one might assume to exist (according to the scenario author), based upon all available information up to that point. A subject's overall score for a routine or harass scenario was then obtained by averaging scores for individual pages. However, if, at any point in a routine or harass scenario, a subject had decided to attack, then his scenario score was the value from his appropriate utility table corresponding to an attack action and a Red intent of routine, for a routine scenario, or of harassment, for a harass scenario.

For attack scenarios, the scenario author identified the approximate time, in his opinion, the first Red weapon could have struck the Blue force, given the unfolding scenario events. He also identified two additional times, the "attack-late" and "stage-late" times. The attack-late time was the latest time Blue could have launched an anticipatory attack which would have gotten weapons on all Red targets prior to Red launching weapons. The stage-late time was the latest time, in the scenario writer's opinion, that Blue could have commenced taking appropriate defensive measures (e.g., general quarters and launching alert aircraft) to reach a state of full defensive readiness by Red weapon impact time. To avoid biasing, all these times were identified by the scenario author before any data inspection occurred.

Utilizing these times, a subject's score for an attack scenario was determined as follows. If, at any point in the scenario prior to the attack-late time, the subject decided to attack, his score for that scenario was the value from his appropriate utility matrix corresponding to the Blue attack/Red attack combination. However, if he chose to attack after the attack-late time, his scenario score was a linear interpolation, based upon the tardiness of his attack decision, between his utilities for the Blue attack/Red attack combination and, depending upon his action decision just prior to the attack decision, the Blue stage/Red attack combination or the Blue routine/Red attack combination. If a subject never made an attack decision in an attack scenario, his score was determined in a similar manner by utilizing the "stage" row of his utility matrix and the stage-late time. There were no cases where a subject decided to maintain routine operations throughout an attack scenario. Since the values from the utility matrix were the subject's own estimates of the cost of various outcome, and because these utility scores were adjusted for timeliness, an approximation of the actual outcome of the scenario could be calculated even though the scenario was not continued to its conclusion.

DISTRIBUTION LIST

Chief of Naval Operations (OP-914), (OP-943), (OP-987P10), (OP-987P7)
Chief of Naval Personnel (Pers-10c)
Chief of Naval Education and Training (N-5), (N-2), (005)
Chief of Naval Technical Training (Code 016)
Chief of Naval Education and Training Support
Chief of Naval Education and Training Support (01A)
Chief of Naval Material (NMAT 034), (NMAT 035)
Chief of Naval Research (Code 1021P), (Code 200), (Code 230), (Code 431), (Code 434), (Code 436), (Code 437), (Code 452) (3), (Code 455) (5) (Code 450) (4), (Code 458) (2)
Chief of Information (OI-2252)
Commander Training Command, U.S. Pacific Fleet
Commander Training Command, U.S. Atlantic Fleet (Code N3A)
Commander, Naval Electronics Laboratory Center (Code 3400)
Commanding Officer, Naval Training Equipment Center (Code 530), (Code 4701), (Code ELEX-03)
Commanding Officer, Fleet Combat Direction Systems Training Center, Pacific (Code 00E)
Commanding Officer, Naval Education and Training Program Development Center
Commanding Officer, Naval Training Equipment Center (Code N215)
Commanding Officer, Naval Damage Control Training Center
Commanding Officer, Naval Development and Training Center (Code 0120)
Commanding Officer, Naval Aerospace Medical Institute (Library Code 12) (2)
Superintendent, Naval Postgraduate School
Director, Training Analysis and Evaluation Group (TAEG)
Army Research Institute for Behavioral and Social Sciences
Coast Guard Headquarters (G-P-1/62)
Personnel Research Division, Air Force Human Resources Laboratory (AFSC), Lackland Air Force Base
Occupational and Manpower Research Division, Air Force Human Resources Laboratory (AFSC), Lackland Air Force Base
Technical Library, Air Force Human Resources Laboratory (AFSC), Lackland Air Force Base
Technical Training Division, Air Force Human Resources Laboratory, Lowry Air Force Base
Flying Training Division, Air Force Human Resources Laboratory, Williams Air Force Base
Advanced Systems Division, Air Force Human Resources Laboratory, Wright-Patterson Air Force Base
Program Manager, Life Sciences Directorate, Air Force Office of Scientific Research (AFSC)
National Research Council
National Science Foundation
Defense Documentation Center (12)

ONR INFORMAL DISTRIBUTION LIST

NAVY

1 Mr. L. A. Aarons
R&D Plans Division
Office of the Chief of Naval Operations (OP-987C)
Washington, D.C. 20350

1 LT Brenneman
COMOPTEVFOR
Norfolk, VA 23511

1 Dr. E. Gloye
Director, ONR Branch Office
1030 East Green Street
Pasadena, CA 91106

1 Mr. R. Lawson
Director, ONR Branch Office
1030 East Green Street
Pasadena, CA 91106

1 Dr. J. Lester
Director, ONR Branch Office
495 Summer Street
Boston, MA 02210

1 Dr. Chantee Lewis
Management Department
Naval War College
Newport, RI 02840

1 M. L. Metersky
NAVAIRDEVCEN (Code 5424)
Warminster, PA 18974

1 Mr. Victor Monteleon
Naval Electronics Laboratory Center (Code 230)
San Diego, CA 92152

1 LCDR E. Neely
Commander, Naval Electronics Systems Command
C3 Project Office
PME 108-1
Washington, D.C. 20360

1 Dr. Gary Poock
Operations Research Department
Naval Postgraduate School
Monterey, CA 93940

1 Psychologist
Director, ONR Branch Office
536 South Clark Street
Chicago, IL 60605

1 Mr. Arnold Rubenstein
Naval Material Command (NAVMAT 0344)
Department of the Navy
Washington, D.C. 20360

1 CDR Richard Schlaff
NIPSSA
Hoffman Bldg. #1
2461 Eisenhower Avenue
Alexandria, VA 22331

1 Dr. John Shore
(Code 5403)
Communications Science Division
Naval Research Laboratory
Washington, D.C. 20375

1 Dr. Alfred F. Smode
(Code N-00T)
Training Analysis and Evaluation Group
Naval Training Equipment Center
Orlando, FL 32813

1 LCDR D. A. Spaugy
Navy C3 Architecture Division
(OP-943)
Office of the Chief of Naval Operations
3801 Nebraska Avenue, N.W.
Washington, D.C. 20390

1 LCDR Charles Theisen
Naval Air Development Center
(Code 4024)
Warminster, PA 18974

ARMY

1 Dr. Robert Andrews
Organizations & Systems
Research Laboratory
U.S. Army Research Lab
1300 Wilson Boulevard
Arlington, VA 22209

1 Dr. Joseph Zeidner
Director, Organization and
Systems Research Laboratory
U.S. Army Research Institute
1300 Wilson Boulevard
Arlington, VA 22209

AIR FORCE

1 LT COL David Dianich
HQS Tactical Air Command
Langley AFB, VA 22065

1 Dr. Donald A. Topmiller
Chief, Systems Effectiveness
Branch
Human Engineering Division
Wright Patterson AFB, OH 45433

MARINE CORPS

1 Dr. A. L. Slafkosky
Scientific Advisor
Commandant of the Marine Corps
(Code RD-1)
Washington, D.C. 20380

DEPARTMENT OF DEFENSE ORGANIZATIONS

1 CAPT Roger Granum
Office of Assistant Secretary of
Defense (Intelligence), Pentagon
Washington, D.C. 20301

1 LT COL Henry L. Taylor, USAF
OAD (E&LS) ODDR&E
Pentagon, Room 3D129
Washington, D.C. 20301

1 Dr. Robert Young
Director
Cybernetics Technology Office
Defense Advanced Research Projects Agency
1400 Wilson Boulevard
Arlington, VA 22209

OTHER DOD

1 Dr. H. W. Sinaiko
Smithsonian Institution
801 North Pitt Street
Alexandria, VA 22314

OTHER

1 Mr. Harold Crane
CTEC, Inc.
7777 Leesburg Pike
Falls Church, VA 22043

1 Dr. Amos Freedy
Perceptronics, Inc.
6271 Variel Avenue
Woodland Hills, CA 91364

1 Mr. Gary W. Irving
Integrated Sciences Corporation
1532 Third Street
Santa Monica, CA 90401

1 Dr. Gary Lucas
System Planning Corporation
1500 Wilson Boulevard
Arlington, VA 22209

1 Mr. William Martin
Analytics, Inc.
1405 Colshire Drive
McLean, VA 22101

1 Dr. A. C. Miller, III
Stanford Research Institute
Decision Analysis Group
Menlo Park, CA 94025

1 Dr. H. L. Morgan
University of Pennsylvania
Wharton School
Philadelphia, PA 19174

1 Dr. C. Peterson
Decisions and Designs, Inc.
8400 Westpark Drive, Suite 600
McLean, VA 22101

1 Mr. George Pugh
General Research Corporation
7655 Old Springhouse Road
McLean, VA 22101

1 Mr. Victor Rowney
Stanford Research Institute
Naval Warfare Research Center
Menlo Park, CA 94025

1 Mr. J. W. Stump
Gruman Aerospace Corporation
Bethpage, NY 11714

1 Mr. Ralph M. Tucker
Martin Marietta Aerospace
Mail Stop 8105
Denver Division
P. O. Box 179
Denver, CO 80201